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1950 ANNUAL MEETING

Biggest Ever

Albert C. Hazard, Detroit Section chairman (left), welcomed the 3600 members and guests who attended the 1950 Annual Meeting dinner. Robert L. Biggers, president of the Fargo Division, Chrysler Corp., was master of ceremonies, and Gen J. Lawton Collins, Chief of Staff, U. S. Army (right), was the principal speaker

TECHNICAL attendance at top sessions was the number of people permitted by fire laws to occupy the Book-Cadillac's biggest ballroom during the 1950 SAE Annual Meeting in Detroit, Jan. 9-13. "Standing room only" characterized more sessions than ever before at this gathering where total attendance edged up over last year's high and where discussions set new marks for both scope and penetration.

Reason-why explanations of two new passenger car automatic transmission designs rated top billing for the week, but every branch of the Society's engineering activity flared with fresh-information papers of high technical significance. The annual business session of the Society was held on Tuesday, Jan. 10 at 8 p.m.

Noteworthy throughout the meeting were sessions and papers which combined data for specialists with definite appeal for all automotive engineers. Typical was the session at which Canadian designers parried deftly sharp questions about the new Avro C-102 Jetliner; the one where it was proved that 150 mpg *can* be obtained in operation of a full-sized American car; another where pathfinding research in fuels and engines was made dramatic as well as specific; another where hitherto hush-hush data about soil-vehicle relationships of military units were revealed for the first time; and still another where vocational opportunities for air transport engineers were detailed.

Typical of these all-for-one and one-for-all sessions was the annual dinner at which General J. Lawton ("Lightning Joe") Collins, U. S. Army chief of staff, voiced his belief that peace can and must be preserved, but warned that "without the urgency of war, we in the Army, and you in industry, must guard constantly against the tendency to become preoccupied with our own individual problems, and go our separate ways. . . . In a free democracy such as ours," he said, "we do not focus the interest of our citizen by force upon national problems. Instead, we place our dependence upon the greater strength of voluntary and spontaneous interest of our citizens—as is so admirably exemplified by the Society of Automotive Engineers."

Master of ceremonies at the dinner was Robert L.

Biggers, president, Fargo Division, Chrysler Corp., who was introduced to the 3600 members and guests by Detroit Section Chairman A. C. Hazard, Chevrolet Division, GMC.

Speaking at the dinner prior to Gen. Collins, 1949 SAE President Stanwood W. Sparrow stressed "eagerness" as a present and major ingredient evident in the success of SAE—and 1950 President James C. Zeder emphasized that SAE stresses no selfish interest in its work of encouraging the interchange of engineering knowledge.

Gen. Collins Tells Of Army Progress

Gen. Collins told of assembly-line operations by which the Army is reconditioning and returning to use ground vehicles and equipment left to rust and rot all over the world when the American public demanded "bring the boys home" immediately after Japan caved in. He described the development program currently in action on tanks and other equipment, mentioning particularly a new light tank which is just being put into actual production and improved fire-control for anti-aircraft guns capable of tracing and hitting jet planes.

He said in part:

"The haste of our demobilization in World War II was such that troops virtually had to walk off and leave their equipment. We found that we had vast quantities of it—some serviceable and some unserviceable—and not enough men to maintain it. . . . We decided to concentrate equipment in occupied areas where adequate labor supplies were available, such as Japan. . . . Recently, I witnessed one part of our overhaul and rebuild program. I saw unserviceable engines taken from vehicles, which we have had to leave in the open for years, brought in at one end of a disassembly-reassembly line, stripped down, then built up again with repaired parts and a minimum number of new parts where necessary, and then taken off the other end of the line as good, serviceable engines.

"We have about 60,000 general-purpose Army and Air Force vehicles to rebuild in Japan. We are processing at the rate of about 1,000 a month.

"In the field of tanks, we have some very fine prototypes and experimental models. Now that we have prototypes of superior tanks, we plan to go into production on all types as soon as possible. . . . Our progress in airborne equipment includes development of a prototype of a plane that can carry a tank—a significant achievement. We have also developed planes and equipment that have successfully dropped the "Jeep" and the 105 mm howitzer.

"As the speed of aircraft has increased with the introduction of jet propulsion, our weapons to combat these faster aircraft have had to improve correspondingly.

"We cannot afford the luxury of a peacetime security based upon stockpiling the vast quantities of modern munitions we would need if war should come. We must instead seek our security in the continuous development of munitions superior to those of any potential enemy, and in the ability to mass-produce them should the need arise."

1949 SAE President Stanwood W. Sparrow (left) and 1950 SAE President James C. Zeder

Zeder Sees SAE "Unique and Interesting"

"We don't realize what a unique and interesting group we are," said 1950 SAE President Zeder, chairman, Engineering Board, Chrysler Corp., in his brief inaugural address which included the following:

"The trade guilds of the Middle Ages have disappeared from our economic scene, but we still find organizations today which profess to serve the best interests of society and the individual by attempting to restrict the number who can enter a given occupation, and by resisting advances in the technology of this occupation.

"What a contrast to this picture is offered by SAE! The SAE serves no selfish interest. It encourages, rather than restricts, the interchange of engineering knowledge. The various cooperative activities which it has established have enabled a better product to be brought to the consumer at a lower cost. It is organized and operated for the express purpose of service to the automotive engineer, the automotive industry, and the American people.

"As an organization, SAE has another unusual quality. Tough-minded, hard-fighting, highly competitive automotive engineers go to an SAE meeting and completely forget competitive animosities in the joint pursuit of mutual problems and interests.

"The automotive industry has a pace and a rhythm unmatched by any other industry. . . . SAE has been at least partly responsible for this by the way it has stimulated the systematic application of engineering knowledge to a mass-production industry."

Sparrow Spots Eagerness As a Sign of SAE Health

1949 SAE President Sparrow, vice-president of engineering, Studebaker Corp., talking of the elements by which success can properly be judged, said in part:

"Neither size nor the amount of money in the bank is an altogether satisfactory basis on which to judge the health of an individual or a society. An authority on philosophy once stated that 'wherever a process of life communicates an eagerness to him

who lives it, there the life becomes genuinely significant'. . . . If this be good philosophy—and I suspect that it is—then no one can doubt that the SAE is making a significant contribution to engineering progress.

"Eagerness is very much in evidence throughout the Society. . . . Most heartening is the fact that this eagerness is not confined to wishing, but manifests itself in a willingness to work to make the cherished dreams come true.

"So long as this attitude prevails, we may make mistakes, but we *shall* make progress."

Stiffer Service Needs Shape Plane, Vehicle DESIGN TRENDS

Based on discussions and 11 papers presented at one Diesel Engine Session, one Aircraft Powerplant session, two Transportation and Maintenance sessions, one Body session, two Truck and Bus sessions, and two Engineering Materials sessions. . . . "Piston Ring Design and Application and Their Effect on Wear," by **A. M. Brenneke,** Perfect Circle Corp. . . . "High Altitude Aircraft Oil Systems," by **F. E. Carroll, Jr.,** Air Materiel Command . . . "Driving Aircraft Accessories Remotely from the Aircraft Engine," by **H. R. Shows,** Air Materiel Command. . . . "Brakes, and Brake Lining Characteristics," by **J. G. Oetzel,** Warner Electric Brake Mfg. Co. . . . "Better Exhaust Systems for Trucks and Buses," by **E. E. Bryant,** Nelson Muffler Corp. . . . "Body Styling Today," by **Raymond Loewy,** Raymond Loewy Associates. . . . "Air Conditioning of Automotive Vehicles," by **A. T. Browne,** ACF-Brill Motors Co. . . . "Full Vacuum Controlled Ignition System," by **C. W. Rainey,** Ford Motor Co. . . . "A Method of Predicting Road Performance of Commercial Vehicles," by **A. F. Stamm** and **E. P. Lamb,** Chrysler Corp. . . . "Gaskets as Engineering Materials," by **J. P. Wilson,** Ford Motor Co. . . . "Brake Drum Materials," by **F. J. Walls,** International Nickel Co., Inc. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

NEW combinations of known materials and design principles were shown by aircraft and motor vehicle engineers at the meeting to be the answer to longer life and resistance to increasingly tough operating conditions. In most cases heat—its control, ejection, or generation—emerged as the crux of the problem.

Getting rid of hot exhaust gases in motor vehicles, particularly trucks and buses, was said to be challenging muffler designers because of conflicting and more stringent requirements imposed by engine designer, vehicle maker, fleet operator, the driver, and the public.

Stepped up performance has made the average engine more susceptible to conditions affecting both incoming air and outgoing exhaust, leaving less space for the muffler and its connecting piping. Vehicle makers put the squeeze on muffler designers because they want equipment that will carry more payload, move faster, and weigh less. Long muffler life and easy maintenance were cited as chief demands of the vehicle operator. And while truck and bus drivers alike believe noise is indicative of power, the public is voicing strong opposition to exhaust noise. Said one muffler specialist, "This leaves us in the middle with the specification actually laid down by one engine maker of building a muffler 'noisier but quieter.' "

Major emphasis was given to the antipathy to undue noise, said to be shared by operators and manufacturers alike. Many feared that growing public resentment to noise would produce legal restrictions as well as bad public relations for the trucking industry.

Ability to withstand heat was cited as a main requirement for gaskets. Equally important in gasket selection are the essentials of compressibility, recovery, resistance to the fluid or gas sealed, and uniformity.

While too much heat is generally the source of engineering problems in most automotive design work, diesel engine cylinder corrosion, many agreed, chiefly stems from low coolant temperatures, due either to design or operating conditions. Temperatures below 120 F were said to be conducive to abnormal wear, and water jacket temperatures maintained at 160 F or higher were recommended for lowest corrosive wear.

Scuffing, another form of cylinder wear, was singled out as a design consideration rather than a wear problem.

Air conditioning engineers felt their job in bus design poses a unique heat problem in automotive thermodynamics . . . heat introduction in the winter, heat removal in the summer. Providing uniform temperature in the passenger compartment is less than simple, they said, if economy in weight, space, and operation are to be designed into the equipment.

Disposal of heat generated in the conversion of kinetic energy by the brakes is becoming tougher for suppliers of both brake drum and brake lining materials, discussion at the meeting revealed. Emphasis on vehicle appearance has largely switched

1. Past-Presidents Herbert W. Alden (left), and Ralph R. Teetor with Major-Gen. E. L. Ford, Chief of Ordnance, Department of the Army (right)

2. B. B. Bachman, SAE treasurer and a past-president (left), with Rear-Admiral A. M. Pride, Chief, Bureau of Aeronautics, Navy Department

3. Harlow H. Curtice, executive vice-president, General Motors Corp. (left), with Major-Gen. Floyd L. Parks, Chief of Public Information, Department of the Army

4. B. E. Hutchinson, vice-president and chairman of the Chrysler Corp. Finance Committee (left), and K. T. Keller, president of Chrysler Corp. with Lt.-Gen. B. K. Wolfe, Deputy Chief of Staff, Materiel, USAF (right)

5. Past-Presidents Arthur Nutt (left), and A. T. Colwell with Brig.-Gen. Phillips, Chief of Research and Development, USAF (right)

the brake from a heat exchanger to a heat reservoir, brake men lamented.

Extent of the problem was brought home by the explanation that a fast, large car develops over 1,500,000 ft-lb of kinetic energy at top speed, the heat equivalent of which is 1925 Btu . . . enough heat to melt 13.5 cu in. of cast iron weighing 3.5 lb.

Higher vehicle weights and speeds, and growing need for ability to go up and down steep grades are complicating brake design—from the drum and lining standpoint.

In friction materials, it was said, terrific heat

stresses are built up even before plastic infusion temperatures are reached. Resins in resin-bonded materials begin to dissociate at 600 F, and some even soften and lose their friction values at lower temperatures. Those that resist temperatures better are good insulators, and simply "pass the buck," since heat generated must then go into the drum or metal.

Sintered metallic friction materials represent an effort to boost disintegration temperatures, and to conduct away more heat from the surface on which it is generated, by conducting it into the lining, shoe, and drum, brake specialists noted. But plates and drums become heat-checked so that the main cause seems to be the temperature differentials within the metal.

To one brake engineer this means that he and his confreres are working so close to the limit of all known materials that they are within the zone of diminishing returns. He urged examination of characteristics of all available materials so that engineers could use them within their limitations. Also recommended was a study of the nature of heat and temperature.

According to reports of airplane brake drum failures, brake heat difficulties are not confined to motor vehicles. Here high loading per unit of area and pound of drum impose critical design limitations. Airplane drums must absorb and hold about 92% of the kinetic energy at 1075 F at the end of the stop. Brake parts absorb about 6% of the heat generated and 2% is dissipated through the drum during the stop. Aircraft brake designers, it was reported, try to provide enough mass and strength without developing too high a temperature differential between the drum ID and OD.

Flight conditions as well as ground operations are creating more stringent design criteria for airplane components and systems. For example, high-altitude flying is forcing a redesign of engine lubricating systems because they maintain insufficient oil pressure.

Driving aircraft engine accessories also was claimed to be increasingly a more difficult job. Because higher performance is being demanded from engines, accessory sections on airplane powerplants are shrinking, while the accessories themselves are growing in both size and number.

Aircraft men concurred that the answer to these difficulties lies in remotely driven accessories. The 25% weight saving possible with constant-speed, remotely-driven accessories, as against operating over a speed range when driving directly from the engine, should give added impetus to the move, one engineer opined.

More exacting motor vehicle performance and the cry for simplified maintenance also will bring changes in car design, particularly ignition systems. A full vacuum-controlled ignition system, now used in Ford cars and commercial vehicles, replaces the two mechanisms for spark advance (centrifugal weights and a vacuum-actuated diaphragm) in conventional systems with a single vacuum control.

Because torsional vibration does not affect spark timing of this system as it does the centrifugal weight assemblies, this new ignition system minimizes spark timing spread, according to its designers. Maintenancewise, it was claimed that simplification of assemblies, elimination of parts, and the longer life inherent in the design facilities servicing of the distributor.

Car stylists said they also are aiming for utility in design, but are being stymied by car sales management. The trend toward heavier and bulkier cars, said one stylist, is not in the best interests of the car-buying public. He labelled senseless a 3500-lb machine for transporting two persons . . . 92% of cars on the highway travel with empty back seats. Stylists are hoping to reverse this retrogression, aiming for utility, simplicity, and weight reduction in forthcoming models.

Truck engineers and operators agreed that the cost-conscious transportation industry wants vehicles tailored to specific operations. They cited techniques for predicting performance as the way to select the best truck-and-engine combination for the job.

Fleet men said they want higher road speeds and better grade-ability. Profitable operation hinges on determination of the right amount of power needed to satisfy these service requirements most economically. Too little power will impair perform-

Continued on page 59

Session Chairmen

The 1950 SAE Annual Meeting was planned by the 1949 SAE Meetings Committee and the 12 Professional Activity Meetings Committees.

The 1949 Meetings Committee operated under the general chairmanship of G. A. Delaney and included L. W. Fischer, vice-chairman; W. K. Creson, G. W. Laurie, William Littlewood, R. R. Teetor, and the Meetings Chairmen of the 12 Professional Activities.

Chairmen of the technical sessions of the meeting were M. M. Roensch, Ethyl Corp., Detroit; R. E. Geror, Northwest Airlines, Inc., St. Paul, Minn.; A. H. Fox, Standard Oil Co. of Indiana, Whiting; P. E. Hovgard, Baltimore, Md.; E. W. Conlon, University of Michigan, Ann Arbor; H. L. Moir, Pure Oil Co., Chicago; H. D. Hoekstra, Civil Aeronautics Administration, Washington, D. C.; A. O. Willey, Lubrizol Corp., Cleveland; L. A. Gilmer, Oliver Corp., Charles City, Iowa; S. W. Sparrow, Studebaker Corp., South Bend, Ind.; Joseph Geschelin, Chilton Co., Detroit; G. A. Delaney, Pontiac Motors Division, General Motors Corp., Detroit; Robert Insley, Continental Aviation & Engineering Corp., Detroit; A. L. Beall, Wright Aeronautical Corp., Wood-Ridge, N. J.; J. L. S. Snead, Jr., Consolidated Freightways, Inc., Portland, Ore.; W. P. Eddy, Jr., Pratt & Whitney Division, United Aircraft Corp., East Hartford, Conn.; Phillip Rothwell, Chrysler Corp., Detroit; M. E. Nuttila, Cities Service Oil Co., New York City; R. A. Terry, Chrysler Corp., Detroit; Lester Beltz, Ford Motor Co., Dearborn, Mich.; J. S. Laird, Ford Motor Co., Dearborn, Mich.; R. W. Roush, Timken Detroit Axle Co., Detroit; and Hoy Stevens, American Trucking Associations, Inc., Washington, D. C.

Surface As Cause of

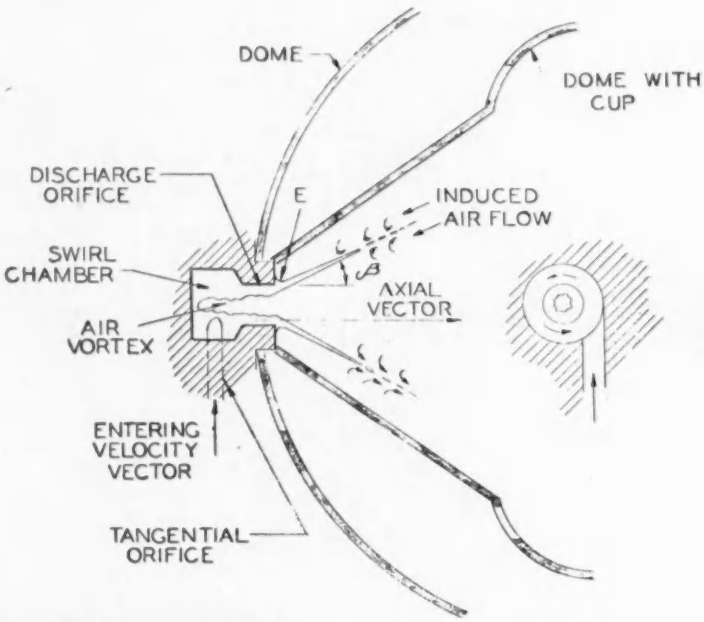


Fig. 1—Diagram of swirl chamber

(This paper will be printed in full in SAE Quarterly Transactions.)

MAJOR need in the field of gas turbine powerplant fuel spray nozzles today is achievement—particularly at low fuel flow rates—of a high degree of atomization plus evenness of distribution.

Swirl-type nozzles are generally well suited to gas turbine burners. But at low fuel delivery, the force of surface tension is strong enough relative to the energy of the fuel flow to interfere with atomization.

This characteristic, plus flow disparities introduced by check valves, is leading to abandonment of simplex swirl nozzles in favor of duplex nozzles.

The swirl (or vortex) type of nozzle has numerous advantages: It is capable of giving good atomization without high velocity of egress into the air. Its thin-wall, hollow cone spray is well adapted for inducing air mixing. Lack of moving parts in fixed-orifice swirl nozzles precludes seizure from dirt, carbon particles, or gasoline gum.

Fig. 1 shows the swirl chamber. Fuel enters the chamber through one or more tangential orifices and, baffled by a shoulder, flows momentarily around the chamber walls. When it escapes through the orifice, the fuel tends to form a cone. As fuel progresses away from the orifice tip, it reaches larger and larger cone diameters. By the law of continuity, film thickness decreases as cone diameter increases. Eventually, film thickness decreases to a point where the film breaks into drops.

* Paper "Practical Conclusions on Gas Turbine Spray Nozzles" was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 6, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

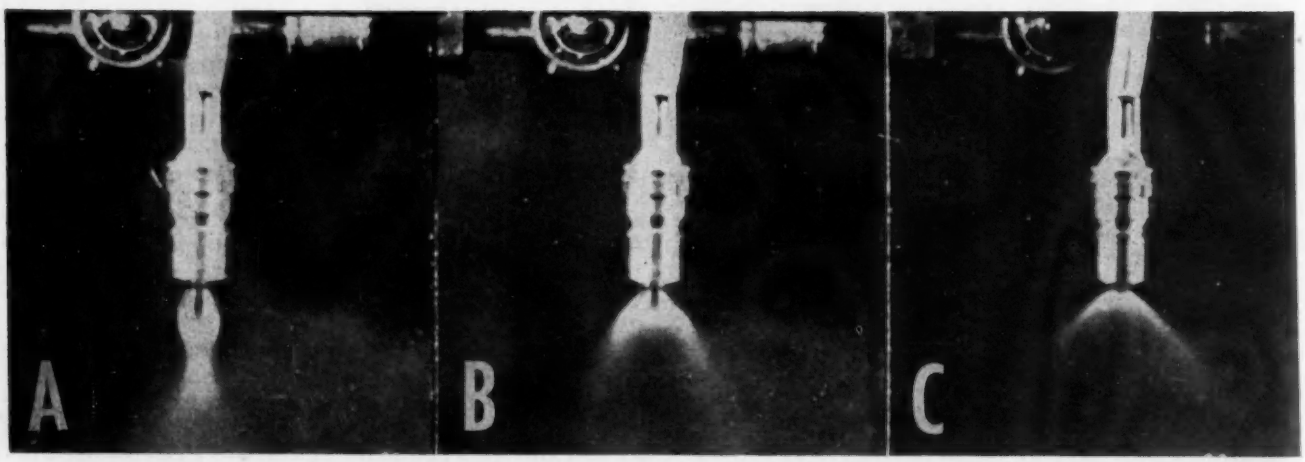


Fig. 2—Visual classification for defining low-flow spray forms

Tension Diagnosed Spray Nozzle Problems

BASED ON PAPER* BY

Frank C. Mock and **Dean R. Ganger**

Manager, Fuel Feed Engineering — Project Engineer

Bendix Products Division, BENDIX AVIATION CORP.

At high flows, events follow this pattern quite closely. (The cone shape is modified somewhat by air pressure reduction inside the cone.)

But at low flows, the force of surface tension is strong enough relative to the energy of the fuel to interfere with atomization. The fuel adheres to the face of the orifice (as at "E" in Fig. 1) and forms glassy "olives" and "umbrellas" instead of continuing cones.

Beginning with the "olives," spray form progresses through three easily recognizable stages as flow is increased. Bendix proposes that these stages, as illustrated in Fig. 2, be adopted as standards for atomization for comparing nozzle forms:

Spray A—Olive Form. This represents the minimum atomization tolerable in service. Single burner tests show that during combustion the airflow and flame tend to break the bubble into very coarse drops, but there would be no certain feed to an ignition spark gap.

Spray B—Glassy Cone. The discharge extends $\frac{5}{8}$ in. from the orifice tip as an unbroken conical film, then breaks into coarse drops. Although the angle of the cone of drops is uncertain, some fuel is

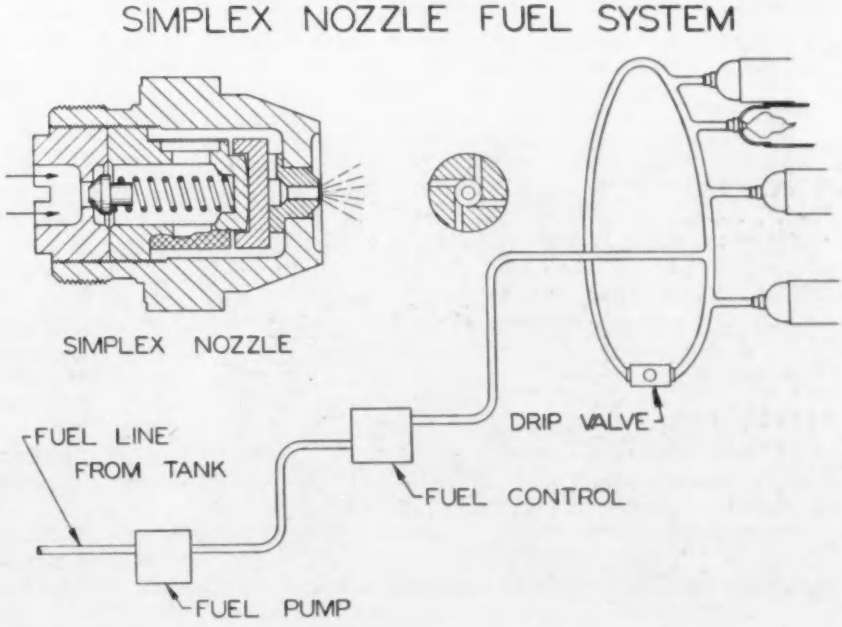


Fig. 3—Simplex nozzle fuel system

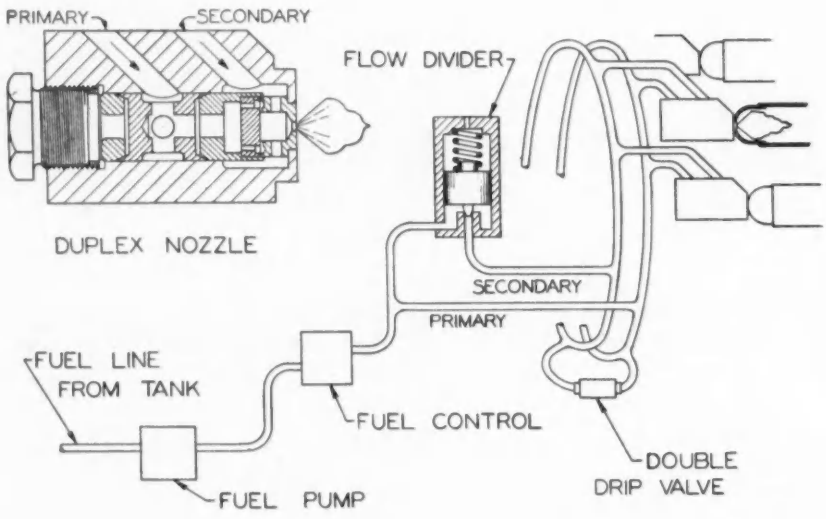


Fig. 4—Duplex nozzle fuel system with two fuel manifolds. (Another duplex nozzle system uses a multiple flow divider with all fuel entering nozzle through one orifice)

fairly sure to reach a properly located ignition point.

Spray C—Complete atomization. Fuel leaves the orifice tip in droplets rather than as a film. Cone wall is thin; cone angle is well defined and normal. Fineness of droplets increases as pressure is raised.

Consideration of the surface tension effect discloses three physical laws—applicable chiefly to the low-discharge range—which many treatises on nozzles seem to ignore:

1. For a given standard of atomization and a given orifice structure, the energy required per pound of fuel is greater as the discharge rate is lower.

2. For a given standard of atomization and a given volume discharge rate, the energy required is greater as the wetted surface of the orifice tip is greater.

3. For a given fuel weight delivery, the actual energy of the fuel droplets and the viscous drag of air into the fuel cone will increase greatly if the cone is changed from the glassy film of Spray A or Spray B to the full spray of Spray C. Consequently, Spray C may burn better with a larger cone angle or with a cup-shaped shield around the spray cone base (as shown in Fig. 1).

The magnitude of these three effects depends on existing fuel viscosity.

These laws account for some of the differences in nozzle designs and their performance. Early turbojets used a simplex design like that shown in Fig. 3. More recent engines use a duplex type similar to that shown in Fig. 4. Expanding swirl nozzles, Fig. 5, have also been proposed.

The simplex design illustrated allows for selective face lapping to maintain the close metering tolerance. It incorporates a check valve to reduce the amount of fuel running into the engine after the fuel supply is cut off. Pressure required is proportional to the square of the flow plus the check valve pressure.

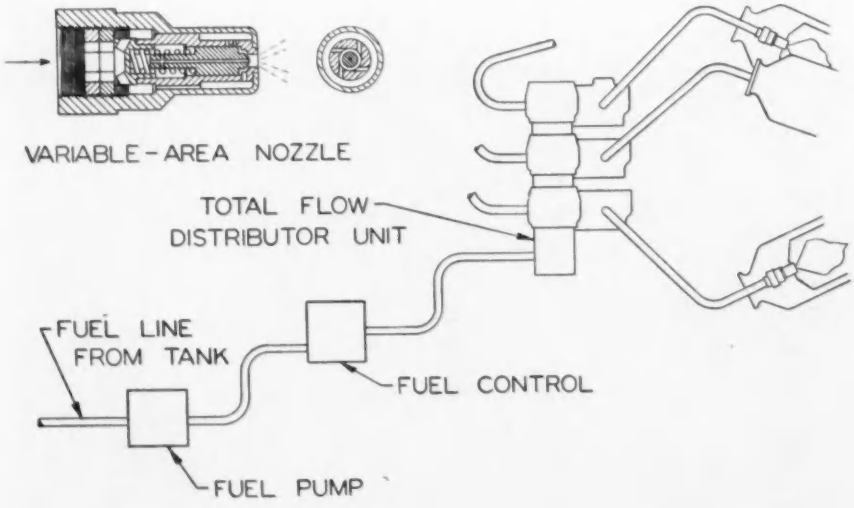


Fig. 5—Variable-area (expanding) nozzle fuel system with total flow distributor

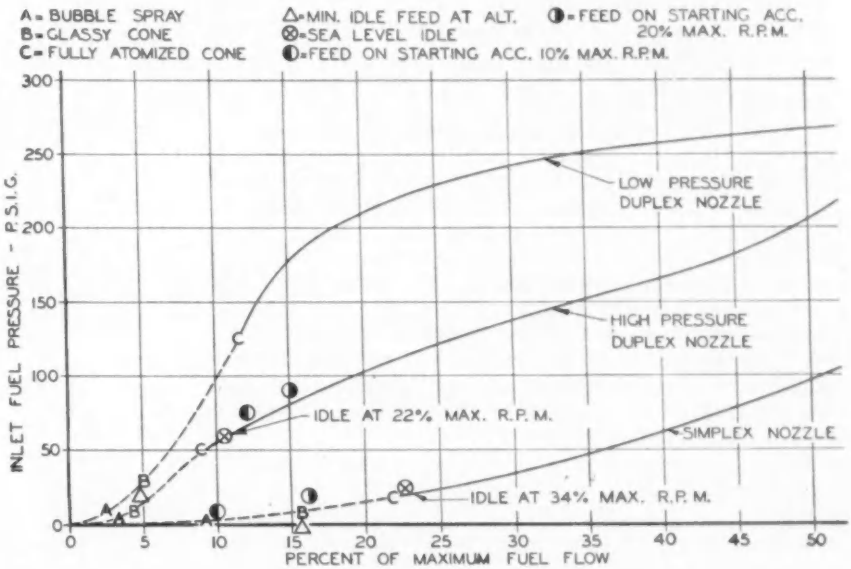


Fig. 6—Low-delivery portion of inlet fuel pressure versus fuel flow curve showing spray forms and four critical engine operating conditions. At higher deliveries, the high-pressure duplex nozzle curve rises well above the low-pressure duplex nozzle curve. (100% maximum fuel flow is taken as fuel delivery required for rated engine rpm at zero ram and 60 F intake air)

The bottom curve of Fig. 6 shows the low-delivery performance of such a simplex nozzle and also four critical low-fuel-demand operating conditions of a particular engine. Three out of four of these critical conditions occur at inferior forms of spray.

If Spray C, the best of the spray forms, were to be used throughout the fuel-flow range, the pressure at the extreme low-delivery end would have to be about 15 psi. Hence, the maximum delivery pressure would be the flow range ratio squared, times 15 psi, plus the check valve pressure. If the flow range ratio were 10 to 1, the maximum pressure would be over 1500 psi.

Some current simplex nozzles use atomizing fuel pressures considerably lower than 15 psi. The low atomizing pressure is masked by a fairly stiff check valve setting. The result is that uniformity of low-end delivery from a common line depends very greatly on absolute uniformity of check valve setting. Tests of nozzles removed from an engine with check valves supposedly undisturbed have shown wide variation in flow—although when the check valves were removed, nozzle flows were alike, showing the valves were to blame for the variation. Check valve variation seems to increase with service time.

Inadequacies of the simplex nozzle lead to development of duplex nozzles.

Prime function of the duplex nozzle—and of expanding types too—is to hold up the energy of atomization at low deliveries. Fuel is fed only through primary entrance orifices for low delivery, through both primary and secondary entrance orifices at higher deliveries. This is the simplest way known to apply the energy needed for good atomization. Uniformity is reasonably easy to control because orifices are fixed.

Although duplex nozzles require slightly higher fuel pressures to achieve Spray C because the central orifice is larger, they achieve Spray C at considerably lower percentages of maximum fuel flow. Fig. 6 shows that high pressure duplex nozzles similar to that shown in Fig. 4 provide Spray C for three out of four low-flow-demand critical engine operating conditions. (These nozzles are considered in connection with an engine different from the one with which the simplex nozzle was considered.)

Extension of these duplex nozzle curves beyond the portion of the pressure-flow chart shown in Fig. 6 indicates that, taking the beginning of Spray C conditions as the minimum flow point, a 16 to 1 flow range can be achieved even with the high-pressure duplex with a maximum fuel pressure of 1700 psi. Or accepting Spray B conditions for minimum flow, the 16 to 1 flow range results in a maximum pressure around 500 psi.

Although designers had hoped to use lower maximum fuel pressures, this 500-psi figure is likely to be the lowest acceptable maximum, due to (1) the increasing range of operating conditions and consequent increased range of fuel flow demanded, (2) higher compressions, and (3) the higher ram pressures resulting from high air speeds.

Expanding nozzles used with a total flow distributor are another approach proposed to the problem of bringing down requirements for maximum fuel pressures. Practicality of the distributor has been demonstrated, but the nozzle appears to offer almost prohibitive construction difficulties.

The location of the variable-area valve in compression temperatures, or higher temperatures, prevents use of flexible diaphragms for multiplying operating force. Metallic diaphragms or sylphons seem prohibitively heavy. So designers must resort to small pistons.

If a piston clearance as small as 0.0002 in. is used, seizure is a problem. Large clearances of 0.003 in. leave room for leakage and increase fuel-pressure requirements for low deliveries. Clearances between these extremes will be sensitive to clogging by grit, carbon particles, or gum in the fuel.

Ease of manufacture and wide available range of fuel flows make the duplex nozzle a better successor to the simplex.

EASIER

Laid to

THE revised SAE Involute Splines Standard, recently approved for publication in the 1950 SAE Handbook, sets up tolerances on fit for the first time—which greatly simplifies manufacture of involute splines. It also is being processed as an American Standard.

These tolerances cover unavoidable manufacturing errors and thereby provide a manufacturing control that facilitates the mating of external and internal involute splines. Under the old SAE Involute Splines Standard, lack of such tolerances on fit made it almost mandatory to fabricate both the internal and external spline in the same shop. If produced at two different points, differences in these unavoidable manufacturing errors inherent to each set-up complicated the mating of splines, despite adherence to dimensional limits of the teeth in the old Standard. This made for cut-and-try gage modifications to make parts fit.

With the tolerances on fit in the revised Standard, eccentricity of the manufactured parts is taken into consideration so that improper fit between mating splines is vastly minimized. These new tolerances stem from the acceptable errors for the Class 3 fit for gears, spelled out in the American Standard on Gear Tolerances and Inspection, ASA-B6.6-1949. The gear tolerances were translated into those for splines, from which the new spline fits in the SAE Standard were derived. With tolerances established, the barrier to gage standards has been removed. A subcommittee of ASA Sectional Committee B-5, of which SAE is a co-sponsor, already has started on this job.

The SAE Involute Splines Standard was revised by the Involute Splines and Serrations Subcommittee, of the SAE Parts and Fittings Committee. C. H. Stanard, formerly of the Buick Motor Division, GMC, has been chairman of the group for seven years.

Vice-chairman of the Subcommittee, G. L. McCain, Chrysler Corp., explains this new tolerance on fits by noting that spline manufacture involves essentially the same processes used in making gears. With gears, a few teeth run together at one time and accuracy is aimed for to get smooth running. Accuracy is desired in splined parts so that they assemble with a minimum clearance or backlash. But the producing machines limit this objective.

McCain notes that if two mating parts could be perfectly made, the amount of clearance between them would be the difference between the space width of the internal spline and the tooth thickness of the external spline.

But because of inherent faults in the machine tool or cutter, or heat-treatment distortion, the following unavoidable errors creep into the splined parts:

1. Accumulated pitch error,
2. Profile error,
3. Lead error, and
4. Out-of-roundness.

When some or all of these errors tend to decrease the clearance, the effect of these errors, deducted from the dimensional clearance, leaves the effective clearance.

McCain describes these four types of errors in terms of the illustration in Fig. 1, which shows a 14-tooth spline shaft and fitting, with the errors somewhat magnified.

Tooth "A", says McCain, has a faulty involute curve or form on the left side, causing it to contact on top and consume what should be a clearance between "A" tooth and "A" space. Tooth "B" is perfect, with clearance on both sides. The circular pitch between tooth "B" and "C" is greater than it should be, so that the effect is to put all the clearance on one side and force contact on the right side.

If now we should have a similar condition on two other teeth opposite to "A" and "C", such as at "J" and "H", continues McCain, the fit of the two parts would be at the four places only if no other errors interfered. Teeth "D" and "E" show the effect of out-of-roundness. The major and pitch diameters

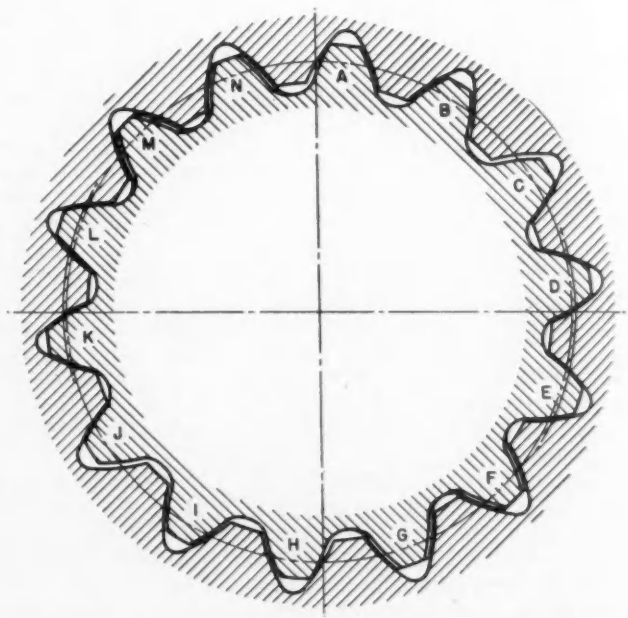


Fig. 1—These enlarged spline fittings depict the types of manufacturing errors which are unavoidable in making involute spline parts, which are being taken into consideration as tolerances in the revised SAE Involute Splines Standard. Tooth "A" has profile error; tooth "C" makes contact on its right side because of circular pitch error between it and tooth "B"; teeth "D" and "E" illustrate out-of-roundness; and teeth "F" and "G" show lead error

SPLINE MANUFACTURE

New SAE Standard

are above those of "A", "B", and "C" and the tooth is shown farther out into the space, consuming the clearance and causing contact. Teeth "F" and "G" illustrate the effect of a lead error. The teeth have been hobbed out of parallel with the axis, and the contact is at one end only.

All of these errors, if added together, prevents the assembly of the two parts, or at least decrease the clearance indicated by dimensions. Fortunately the errors do not occur together often and sometimes even oppose each other so that the effect on the fit tend to cancel.

For example, suppose that the pitch error between "B" and "C" in Fig. 1 was negative, the effect would have been included within the involute error shown at "A", with no further effect on the fit. If errors of pitch occurred cumulatively, between adjacent teeth, the addition of the errors would result in consuming clearance. Thus, the error of pitch should be specified as "the greatest difference in any two teeth between the actual and theoretical tooth spacing on the same circle".

So far, the errors assumed are all on the part with external teeth, says McCain. The internal toothed part, because of its form, is often broached; but in larger sizes especially it may be produced with a shaper cutter. Broaching is the most accurate, assuming that the machines which produce the broach are superior. Therefore a broached internal spline is more accurate than a shaped part.

But either process is subject to some unavoidable errors. And if those errors are in the same direction as the errors in the external spline, the dimensional clearances are not decreased. If the errors run counter to those of the external splined part, then the clearances are cancelled, perhaps even to the extent of creating a local interference.

Since there is little chance that all the possible errors will occur at one time, and in the same direction, the revised SAE Involute Splines Standard establishes 60% of the total of all errors as a fair maximum for computing effective fit.

Vice-chairman McCain points out that a press fit between splined parts may often be nothing more than several local interferences, which would often force the initial torque load on only a few teeth. Such a fit, after some service, might become looser, which would tend to throw the torque load on more teeth. An involute spline tends to center itself, and small imperfections caused by the manufacturing errors, will be worn off; and as this occurs, more teeth will take up the load.

Two years in the making, the revised Standard also features an extensive rearrangement of the dimensional data. All material on each fit is assembled in a single tabulation, instead of being scattered through several different tables, as in the old Standard. Among the other revisions is a change in drawings to show the full fillet type spline, which also led to an expansion of the nomenclature. And the dimensional tables have been extended to show teeth with full addendum.

New data also have been included on shaper cutters and hobs and on a taper fit application. The minor diameter fits that are of limited usage have been placed back of the main tables and data pertaining to them consolidated.

During development of these revisions by the SAE Involute Splines and Serrations Subcommittee, the same job was being done on the American Standard on Involute Splines. Both the SAE Standard and the American Standard will be in substantial agreement.

As a matter of interest, the SAE Subcommittee and its ASA counterpart, a group under Technical Committee No. 13 on Splines and Splined Shafts, consist of the same personnel. They are: Chairman Stanard; Vice-Chairman McCain; S. O. Bjornberg, Illinois Tool Works; H. H. Gotberg, Colonial Broach Co.; J. P. Breuer, Barber-Colman Co.; A. E. Leach, Pontiac Motor Division, GMC; Harry Pelphrey, Michigan Tool Co.; N. Finkelstein, Buick Motor Division, GMC; W. A. Siler, Delco-Remy Division, GMC; G. Trinkle, Illinois Tool Works; Harold Inch, Ford Motor Co.; and J. F. Cramer, Boeing Aircraft Co. Co-sponsors of the ASA Committee are SAE, ASME, American Gear Manufacturers Association, and the National Machine Tool Builders' Association.

SAE is making available the revised Involute Splines Standard together with its companion SAE Standard on Involute Serrations, revised several months ago, in one booklet. This publication, combining the two Standards, SP-35, is available from the SAE Special Publications Department. Price: $1.25 to members, $2.50 to nonmembers. Quantity prices are available on request.

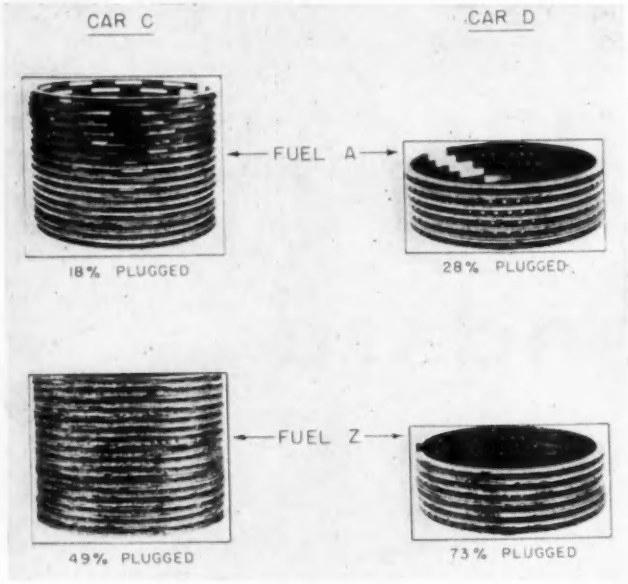


Fig. 1—These piston rings, taken from cars run in controlled road tests, demonstrate the effect of both fuel type and engine design on oil-ring plugging

NEW LAB Piston

EXCERPTS FROM PAPER* BY

L. J. Test and

Supervisor of Automotive Laboratory, Atlantic Refining Co.

THREE cycling laboratory tests have been developed for evaluating factors causing oil-ring plugging—the missing link in present standardized laboratory tests. These procedures indicate the ring-plugging behavior of fuels as well as that of such factors as engine design, lube oil, and operating conditions.

The deposit problem, stemming from light-duty or low-temperature engine operation, has received much study through the CRC FL-2 laboratory test procedure, which evaluates the varnish-forming tendencies of the fuel and the ability of the lubricating oil to keep these fuel-formed deposits in suspension. But the FL-2 test does not throw any light on one of the most detrimental deposit factors in light-duty operation—plugging of piston oil rings.

A 1948 CRC report[1] concludes that "the laboratory FL-2 test does not predict the tendency of a fuel-oil combination to form deposits in all service engines, although it appears that FL-2 ratings probably place the combinations in the same order as average road performance." In this report there are several cases where the FL-2 test predicted quite accurately the amount of piston skirt varnish formed in road operation with a given fuel-oil combination; but the amount of oil-ring plugging on the road was much greater than that produced in the FL-2 test.

The three laboratory precedures evolved for studying ring-plugging factors are: (1) a multicylinder engine test, (2) a CFR engine test, and (3) a Lauson LF engine test.

First step in developing these procedures was to find out the kind of service operations that produced serious ring sticking. Such operations include delivery trucks and passenger cars in stop-and-go service. A road test procedure then was set up to simulate door-to-door delivery service. It consisted of 6000 miles of a cycling type operation. Four each of two makes of cars were used in this test. To make the test more severe, it was run during the winter months; and the themostats were removed from the cooling system since in service they are frequently inoperative. Carburetors were adjusted to give a normal air-fuel ratio of about 10 to 1 under idling conditions.

Two fuels, A and Z, were selected to give an extreme range in composition. A mild detergent-type lubricating oil was used in all tests. After 6000 miles of this cycling type of operation, marked differences in the amount of engine deposits were found, depending on the make of car and the fuel used.

Differences in the amount of oil-ring plugging were especially pronounced, as shown in the photographs in Fig. 1. With Car D, Fuel A gave 28% plugging compared with Fuel Z which gave 73%; whereas with Car C, Fuel A gave 18% plugging and Fuel Z 49%. The effect of car make as well as fuel type can be readily seen from the photographs. Observations of deposits throughout the engines indicated that the procedure used duplicated very closely door-to-door delivery-type service.

It was now known that two widely different fuels varied appreciably in their ring-plugging tendencies in a simulated-service road test, in two different makes of engines. These test results were now available as a basis for the development of laboratory test procedures.

[1] See Coordinating Research Council report of Analysis Panel, Engine Varnish and Sludge Group, CFR Motor Fuels Division, "Evaluation of the Effects of Engine Design, Operating Variables, Fuel and Lubricating Oil Characteristics on Engine Sludge and Varnish," May 12, 1948.

* Paper "Oil-Ring Plugging—A Missing Link in Laboratory Tests," was presented at SAE National Fuels & Lubricants Meeting, St. Louis, Nov. 4, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

TESTS Diagnose Oil-Ring Plugging

C. A. Hall

Assistant Research Coordinator,
Ethyl Corp.

First step in the laboratory was to improve on the available visual method of rating oil-ring plugging, since considerable variation was found to exist between ratings made by various individuals. To solve this problem, an oil-ring rater was designed and developed by The Atlantic Refining Co. This rater, shown in Fig. 2, consists essentially of a cylindrical base, which supports an indexing turret containing the oil ring. The base also contains a photoelectric cell and projection-type light bulb centered within

Plugged Rings Are Oil Gluttons

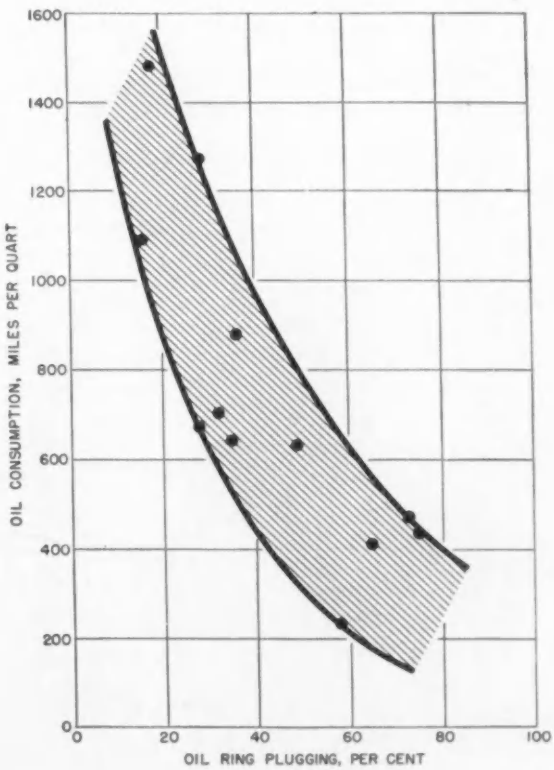
Penalty for oil-ring plugging is increased oil consumption, both road and laboratory studies show.

Effect of ring plugging on oil consumption in terms of miles per quart is shown in the chart at left. It depicts the results using two makes of cars in a controlled road test under light-duty type of operation. Points on this plot represent individual vehicle tests. Several different fuels were used in the test (which ran for 6000 miles), although the same lubricating oil was used in all vehicles.

According to these test data, an increase in oil consumption goes hand-in-hand with increased oil-ring plugging.

As further evidence of this relationship, oil consumptions observations made under CRC L-4 test conditions, on an engine which had previously been run for 90,000 miles in road service, gave similar results. Oil rings were 100% plugged and wear measured at the top of the cylinder bore was 0.007 in. In this "as received" condition, the engine used about six times as much oil as it did after the piston oil drain holes and oil rings were manually cleaned.

Of course, oil-ring plugging is not the only factor—nor even necessarily the main one—in engine oil consumption. Others such as piston-ring and cylinder wear, operating conditions, and engine design also influence consumption rate.



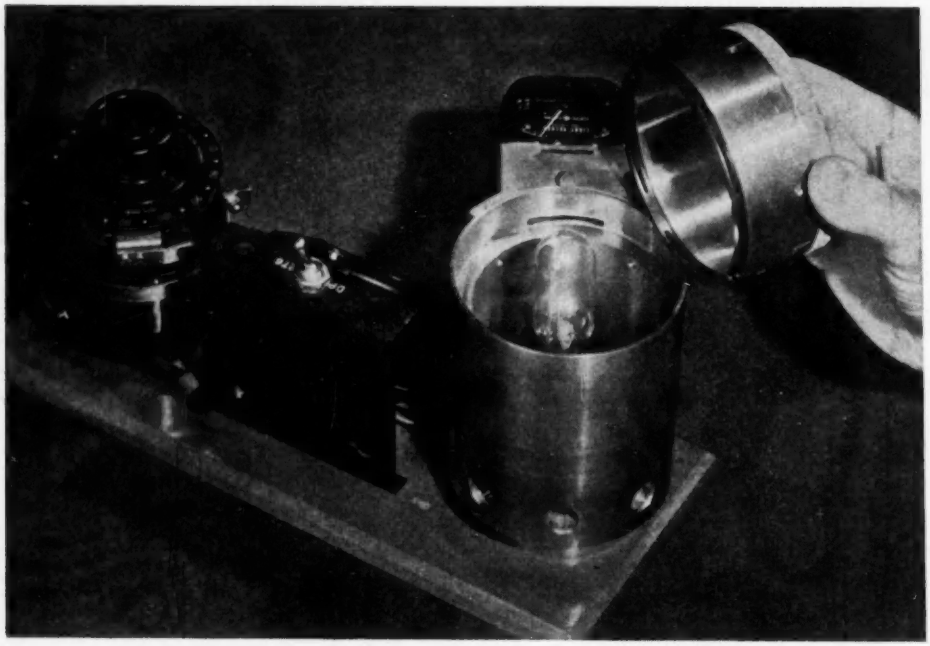


Fig. 2—This gage rates plugging of oil rings percentagewise. It does this by measuring the amount of light, from the lamp bulb, that passes through the ring slot and impinges on a photoelectric cell

the oil ring and turret.

Light from the bulb passes through a given slot in the oil ring, through a somewhat larger slot in the base, and is picked up by the photoelectric cell. The amount of light reaching the photoelectric cell is inversely proportional to the amount of plugging in the ring slot. The turret is indexed so that a light-meter reading can readily be obtained on each slot in the oil ring.

For rating purposes these readings are averaged, and by comparison with the average reading obtained with a standard clean ring, the percent plugging can be calculated. It should be pointed out that this rater evaluates ring plugging in terms of minimum unblocked cross-sectional area of the slots rather than in terms of total amount of deposits in these slots. The rater gives more reproducible results than could be obtained by visual means. It has been found to be accurate within about ± 2.5% when used to rate rings whose slot areas were blocked off by known amounts.

An improved version of this rater has recently been designed which allows for a more rapid determination. A small electric motor is geared to the turret and continuously rotates it and the oil ring. An average reading of the amount of light passing through all the slots is thus obtained in only one observation.

Next move was to develop laboratory procedures which would differentiate between the oil-ring plugging tendencies of Fuels A and Z in the same general way as did the road tests. Since Car D showed the largest spread in ratings from these two fuels, the engine model from this car was used for the laboratory work. Furthermore, the operating conditions were patterned after those used in the road test. The laboratory test cycle finally arrived at consists of 2 hr of rich idling operation, followed by 3 hr of lean operation at 60% load and 2500 rpm.

To adjust and control the air-fuel ratio for both portions of the test cycle, the standard carburetor was modified to include adjustable main and idling jets. Air-fuel ratios were held between 8.5 to 1 and 9.5 to 1 for the idling portion and between 13 to 1 and 14 to 1 for the high-speed operation. The idle mixture ratios are richer than those observed in actual service because an accelerated test procedure was desired. Outlet jacket-coolant temperatures were held at 125 F for idling and at 190 F for the high-speed portion. As will be shown, this procedure differentiated between the ring-plugging tendencies of Fuels A and Z in the same manner as did the road tests.

While the multicylinder engine procedure is a valuable tool for evaluating fuels and lubricants from a ring-plugging standpoint, it has the disadvantage that 250 gal of gasoline are required per test. This limits its use to testing gasolines that can be obtained in quantity at reasonable cost. Because

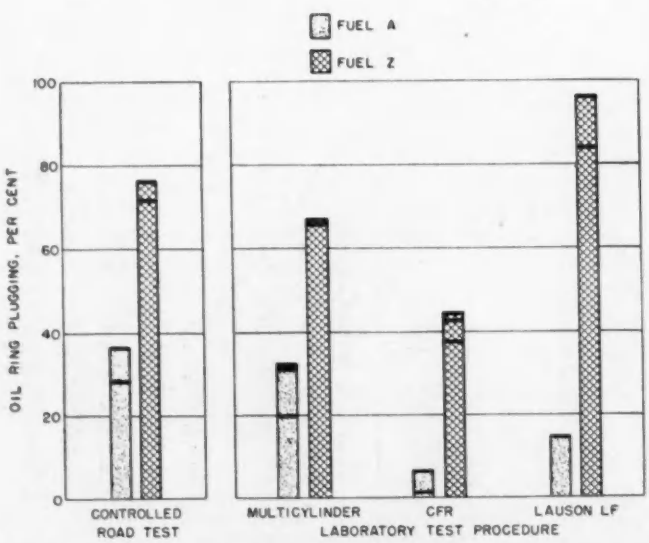


Fig. 3—How the three lab tests for evaluating oil-ring plugging factors compare with the controlled road test

of this limitation, a ring-plugging test procedure was developed using a modified CFR F-4 engine unit.

Only major engine modifications made were replacement of the evaporative cooling system with a water circulating system, and the use of a standard piston and ring assembly made for one of the popular makes of low-priced cars. Operating conditions arrived at are similar to those used in the multicylinder test. The intake air, however, is heated to approximately 170 F during the idling portion of the cycle, to reduce dilution of the crankcase oil.

The cycle consists of 2.5 hr of rich idling operation at 800 rpm, 5 hr of operation at 1800 rpm with manifold pressure of 33 in. hg absolute, and a 16.5-hr shut-down period. This schedule allows one cycle to be completed every 24 hr, and the cycle is repeated until 120 hr of engine operation have been obtained. Continuous operation was tried, but very little ring plugging resulted, indicating that a cooling period was necessary.

While this procedure is an improvement over the multicylinder in that it requires only 90 gal of fuel per test, it is still impracticable for testing costly experimental fuels.

A satisfactory oil-ring plugging test procedure requiring only 30 gal of fuel also was developed using the Lauson LF engine. This engine had been previously modified and used to determine the varnish-forming tendencies of fuels under FL-2 type test conditions. These modifications consisted mainly of: (1) substitution of a Ford V-8 "60" cast-steel piston for the standard aluminum piston, (2) fitting a Ford V-8 "60" steel cylinder sleeve in the cylinder bore, and (3) replacement of the standard engine base with a special casting in which the oil sump capacity was reduced from 1½ qt to 500 ml. These same modifications, plus the addition of a carburetor intake-air heater, were made on the Lauson LF engines used in the oil-ring plugging tests.

The operating conditions and test cycle developed for this engine are somewhat similar to the other test procedures in that there is a cycle which consists of a 2-hr period of idling operation at rich air-fuel mixture and low jacket-coolant temperature, and a 4-hr period of full-throttle, high-speed operation at lean mixture and high jacket-coolant temperature. This cycle is repeated until 120 hr of test operation have been accumulated.

All three of the oil-ring plugging procedures are similar in that they consist of a cycle composed of a rich-mixture idling portion and a lean-mixture, high-temperature portion. This type of cycling operation is believed to be conducive to ring plugging. Although the exact mechanism whereby the oil ring becomes plugged is not known, it is postulated that soot is formed because of incomplete combustion during the rich-mixture idling portion, and resinous materials are formed perhaps during both parts of the cycle. These resins may act as a binder for the soot particles, and may form of pasty mass which is baked hard during the high-temperature operation, plugging the oil rings.

Fuels A and Z, run in the controlled road tests, were used as yardsticks in developing the three laboratory-engine test procedures. As Fig. 3 shows each of these three procedures differentiated between the oil-ring plugging characteristics of these two fuels in the same relative order as did the controlled road tests. Each horizontal black line on a given vertical bar represents the results of a single test. Note that the reproducibility of the various test procedures is quite satisfactory.

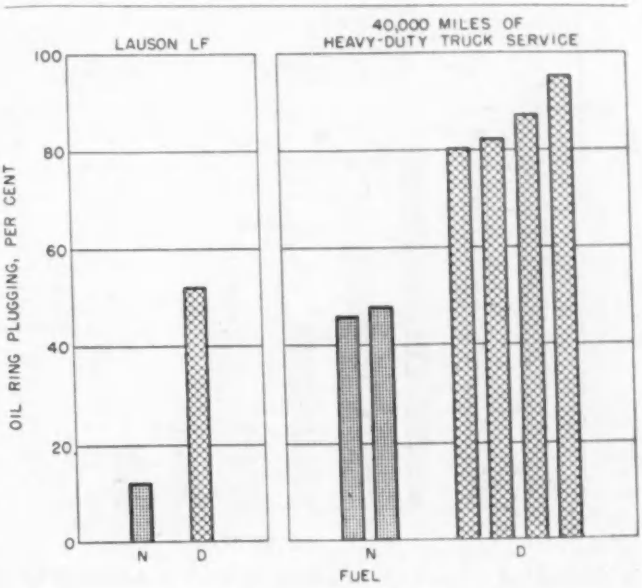


Fig. 4—Comparison of Lauson LF engine lab test results with those obtained from tractor-trailers in 40,000 miles of heavy-duty operation

The tendency of some gasoline-oil combinations to form deposits in the oil-ring slots in most pronounced in door-to-door delivery-type service in cold weather, as previously pointed out. However these same gasoline-oil combinations also may cause oil-ring plugging in heavy-duty truck operation. An example of ring plugging occurring in this type of operation was observed in a recent fleet test run

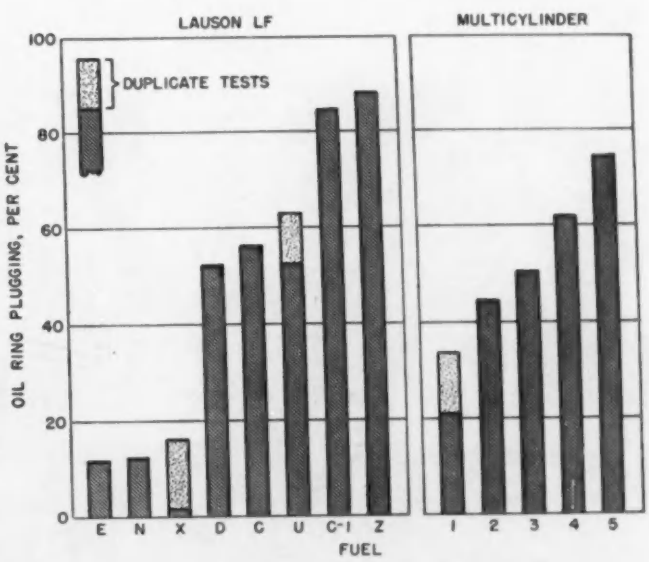


Fig. 5—How different fuels influence oil-ring plugging in both the Lauson LF and multicylinder engine lab test procedures

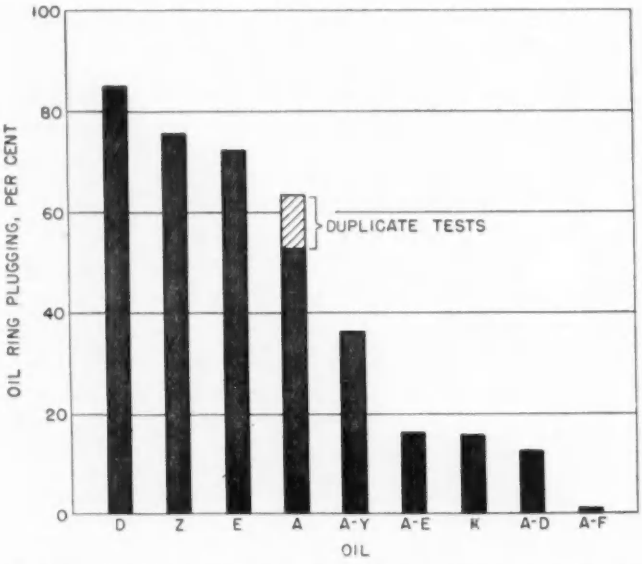


Fig. 6—Effect of different oils on oil-ring plugging, as determined by the Lauson LF engine test procedure

on two different fuels and the same lubricating oil, as shown in Fig. 4.

Two tractor-trailer units run on Fuel N gave 46 and 48% plugging of the oil rings, whereas four units run on Fuel D had their oil rings plugged anywhere from 81 to 95%. A popular make of truck engine was used in this fleet. The vehicles were run in commercial heavy-duty intercity truck operation between Detroit and points in Ohio on a 24-hr a day basis.

These same two fuels were then tested in the Lauson LF oil-ring plugging test procedure and, as shown in Fig. 4, this procedure differentiated between the ring-plugging characteristics of the two fuels in the same relative manner as did the fleet tests run under heavy-duty operating conditions.

These data show that these laboratory procedures have merit in evaluating the oil-ring plugging tendencies of fuels. It is not intended to imply, however, that if these laboratory test procedures show that a given fuel has a considerable tendency to plug oil rings, the fuel will actually plug rings in all types of road operation, regardless of the make of engine and the lubricating oil used. There are other very important factors besides gasoline characteristics that can determine the amount of oil-ring plugging actually encountered.

Evaluating Fuel Characteristics

These laboratory-engine test procedures can be used for determining the relative oil-ring plugging tendencies of various gasolines. Fig. 5 presents the variations in ring-plugging characteristics encountered with a series of gasoline evaluated in the Lauson LF and multicylinder engine procedures. All tests with a given procedure were run with the same lubricating oil, and all of the fuels contained approximately 1.0 ml tetraethyl lead per gal. The cross-hatched portion of the vertical bars represents differences between duplicate tests on the same fuel.

These data show that fuels can vary considerably in their tendencies to plug oil rings. For example, Fig. 5 shows that in the Lauson LF procedure two fuels (E and Z) varied from 12 to 88% in their ring-plugging tendencies. Considerable variation can also be observed in Fig. 5 between five fuels in another group rated by the multicylinder engine procedure.

Lube Oil Effects

Previous investigators have pointed out that lubricating oils vary greatly in their ability to handle and minimize engine deposits resulting from "dirty" fuels both on the road and in the laboratory under FL-2 test conditions. This variation in lubricating oils is also observed in the Lauson LF ring-plugging procedure, as shown by the test results in Fig. 6.

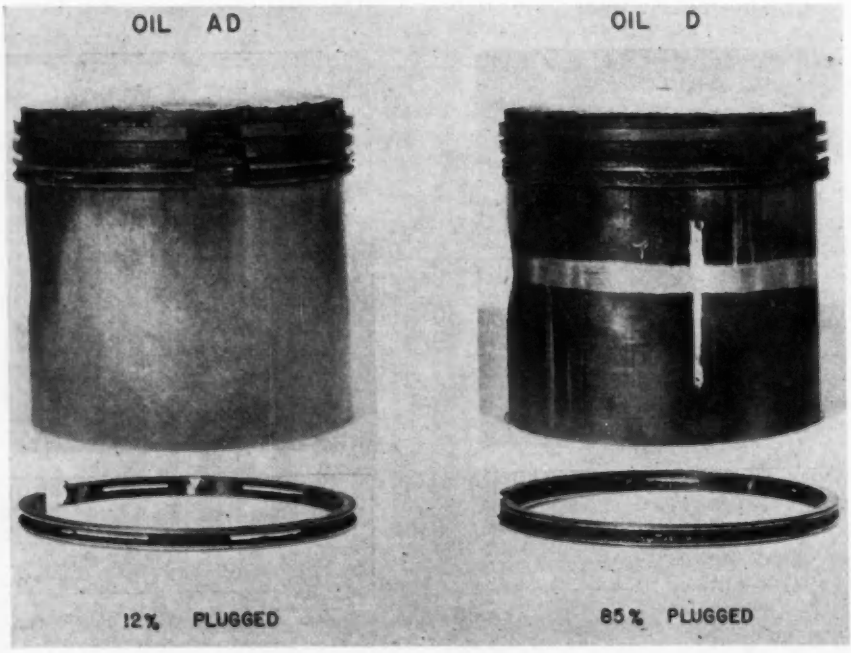


Fig. 7—Effect of oil quality on oil-ring plugging, by the Lauson LF engine test procedure

These tests were run on a "dirty" fuel and the amount of oil-ring plugging varied from zero to 86% over the range of oils used. These oils were SAE 20 grade of straight mineral, premium, and heavy-duty types. Oil A-F, which gave no plugging, was the straight mineral oil A plus 19% of a Series 2 type additive.

Fig. 7 shows photographs of pistons and rings from the tests on oils A-D and D. These data show that under these test conditions, the effect of different lubricating oils on ring plugging appears to be as great as the effect of different fuels.

Among the contaminants that reach the crankcase oil in road operation, especially in door-to-door delivery-type of service, are soot and resin-forming materials from fuels. Because of this, any adequate laboratory test for predicting the road performance of oils in this type of operation should form both of these contaminants.

Some observations made during this ring-plugging work have led to the postulation that certain oils and additives are best suited to cope with resin-forming materials, whereas other oils may be better able to handle the soot formed. The superiority of some oils in prevention of ring plugging may lie in their ability to handle equally well both types of materials. Since the ring-plugging procedures presented here form both soot and resin-forming materials, they are believed to be superior to the FL-2 procedure (which produces essentially resin-forming materials) in evaluating the ability of oils to handle fuel-formed deposits.

Engine Design Studied

Various investigators also have pointed out the significant part that engine design factors can play in minimizing fuel-formed varnish, sludge, and ring-plugging deposits in engines. These test procedures can be used in studies of the effects of design characteristics on ring plugging.

Table 1 shows the effect of oil-ring design on ring plugging as evaluated by the multicylinder and Lauson LF engine procedures. In each engine the principal variation in oil-ring design was an increase in the width of the slot. In the multicylinder engine tests a change in slot width from 0.036 to 0.042 in. reduced oil-ring plugging on the same gasoline-oil combination from an average of 87 to 54%. Similarly an increase in slot width from 0.040 to 0.065 in. in the Lauson LF tests resulted in a large reduction of oil-ring plugging, from 93 to 22%.

Table 1—Effect of Oil-Ring Design on Ring Plugging

Test Procedure	Oil Ring Slot Width, In.	Oil Ring Plugging, %
Multicylinder	0.036	85; 89
	0.042	54
Lauson LF	0.040	93
	0.065	22

This is an example of the usefulness of these procedures in providing the automotive engineer with a rapid and economical means of evaluating engine design factors related to ring plugging.

These procedures also can be used to determine the effect of different operating conditions on ring plugging. An interesting example of their use in this respect is presented in Fig. 8, where the amount of idling operation per cycle was varied in the Lauson LF procedure using three different fuels. These tests were conudcted with the standard amount of 4 hr of full-throttle operation in addition to the idling operation for each of the 20 cycles per test. A high VI straight mineral oil was used as the crankcase lubricant.

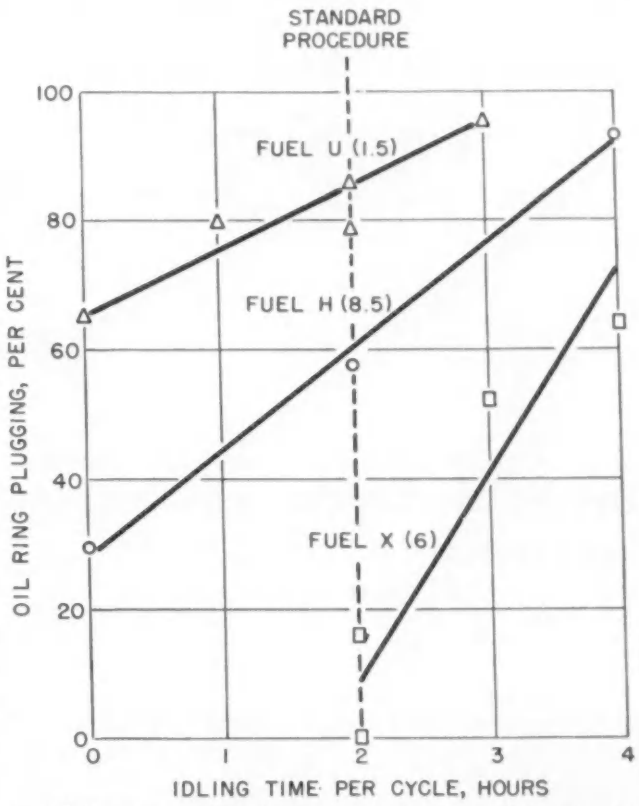


Fig. 8—Variations in idling time wield an influence on oil-ring plugging, these test data show. They were obtained from the Lauson LF test procedure, consisting of 20 cycles—each composed of 4 hr of full-throttle operation and a period of idling for the length of time indicated. Figures in parenthesis represent the FL-2 piston skirt ratings. A rating of 10 signifies "clean"

It is interesting to note that the ring-plugging tendencies of all three fuels increased at least to some degree as the amount of idling time per cycle was increased. However, the exact magnitude of this effect varied considerably for the three fuels. Both Fuel X and Fuel H showed a marked effect of variations in idling time on ring plugging, whereas Fuel U was little affected. This latter fuel gave approximately 83% plugging with the standard idling time of 2 hr per cycle, and as much as 65% with no idling operation.

Why Fuel U should give so much ring plugging with no idling operation is not known. However, this fuel's ring-plugging characteristics are no doubt due in part to its extreme resin-forming tendencies, as indicated by an FL-2 piston skirt varnish rating of 1.5. It can be seen that the three fuels are separated by the Lauson ring-plugging procedure in the same relative order, regardless of the length of the idling portion of the cycle, and furthermore that this order is not predicted by the CRC FL-2 piston skirt varnish ratings of these fuels.

1955 Air Transport

Engine Manufacturer's Viewpoint

by D. J. Jordan
Project Engineer,
Pratt & Whitney Aircraft

IF present expenditures for powerplant development foretell progress by 1955, we conclude that reciprocating engines will be little changed, turboprops will show some improvement, and turbojets will be quite different from those we use today. But the money is being spent on the development of military engines. The best fighter and bomber engine will not necessarily be the best transport engine, even for military transport.

Pratt and Whitney Aircraft is engaged in the development of all three types—reciprocating, turboprop, and turbojet. We have attempted to predict and compare what is likely to be available—not what could be available—for a transport powerplant by 1955.

Fig. 1 shows that, at the representative cruise condition of 350 knots at 25,000 ft, the turpoprop will have a somewhat higher cruise power, a higher net specific fuel consumption, and a much lower in-

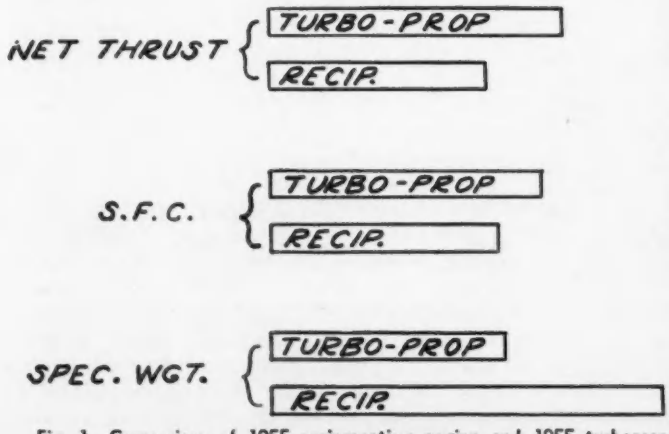


Fig. 1—Comparison of 1955 reciprocating engine and 1955 turboprop at 350 knots and 25,000 ft

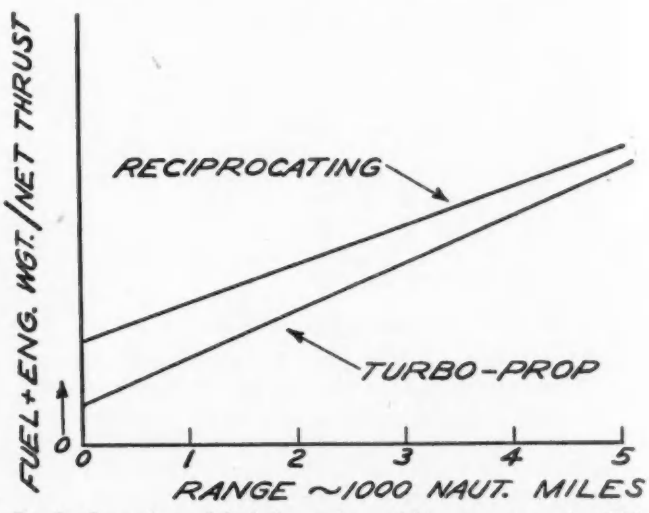


Fig. 2—Comparison of fuel-plus-engine weight versus range for 1955 reciprocating engine and 1955 turboprop at 350 knots and 25,000 ft

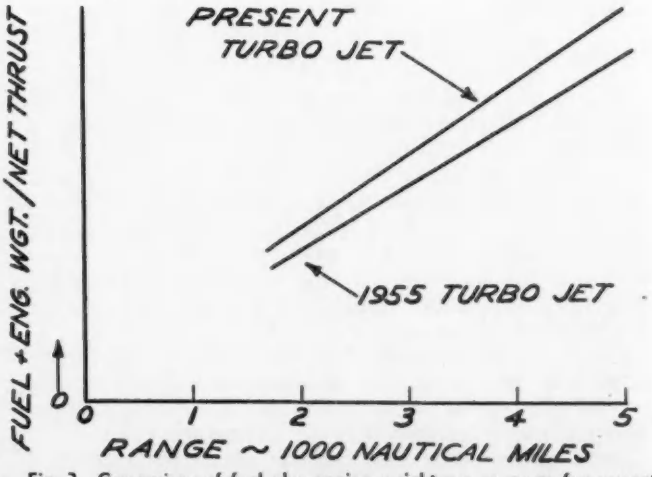


Fig. 3—Comparison of fuel-plus-engine weight versus range for present turbojet and 1955 turbojet at 450 knots and 35,000 ft

Reappraised from* . . .

stalled weight than the reciprocating engine. (A higher speed would be more favorable to the turboprop. The engines are compared on the basis of net thrust at maximum cruise power. Cooling drag and nacelle drag are considered. The weight includes the complete powerplant installation, even the nacelle.)

Fig. 2 shows that, at least up to 5000 nautical miles, the turboprop is better than the reciprocating engine on thrust specific weight of fuel plus engine. (This weight includes fuel tankage weight.) At 4000 nautical miles, the turboprop is about 10% better than the reciprocating engine.

It is not possible to make a direct comparison between a jet engine and a turboprop or reciprocating engine. To attain its full potentialities, the jet engine must be installed in a very special airplane and must operate at flight conditions quite different from those used for the comparison given in Figs. 1 and 2. Perhaps the 1955 jet engine can best be described by comparing it with existing jet engines.

Fuel consumption of jet engines can be improved by improving component efficiencies and and by increasing the cycle pressure ratio. Also, the specific engine weight can be improved by advanced design and better materials. Our opinion of the combined effect of these developments is shown in Fig. 3 for a cruising condition of 450 knots at 35,000 ft. The 1955 turbojets are considerably superior to existing jet engines at long range.

Existing jet engines are small in relation to the inherent size limits for this type of powerplant. Design problems of turbojets, unlike those of reciprocating engines or even turboprops, do not multiply rapidly as size is increased. Therefore, we may expect that a major share of development effort will be directed toward increasing size and that by 1955 larger jet engines will be available.

The trend toward increased size may continue past the 1955 accomplishments. However, the fuel consumption of jet engines tends to approach an inherent lower limit. It is possible that the fuel consumptions obtained by 1955 will represent the major portion of the ultimate capabilities of this engine type.

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* From panel discussion "New Appraisal of 1955 Air Transport," presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 6, 1949. (This panel discussion is available in full in multilithographed form from SAE Special Publications Department. Price: 75¢ to members, $1.50 to nonmembers.)

Canadian Manufacturer's Viewpoint

by E. H. Atkin
Chief Designer
A. V. Roe Canada Ltd

VERY brief experience with a turbojet transport (the Avro Jetliner) brings the overwhelming conviction that not only from the manufacturer's point of view but also from the servicing, maintenance, and repair aspects the turbine-powered transport has all the advantages. This is particularly so if the large and complicated airscrews required for the increased power are avoided.

The turbojet aircraft has:

1. Lower drag.
2. Better control. Due to the absence of rotating slip streams, airflow over the aircraft is much less turbulent and is symmetrical, which improves effectiveness and smoothness of controls. The close-in configuration of the engine improves rudder control.
3. More safety in emergency landings. If the aircraft must be landed with undercarriage up, absence of airscrews makes the operation safer.
4. Decreased engine and airframe maintenance needs. Jet engines require only 25 to 35% of the maintenance that reciprocating engines do. Jet airframes require less maintenance than those conventionally powered because jet engines vibrate less.

Outstanding questions about turbojet aircraft are:

1. *Economy*—Short-range turbojet aircraft with presently available engines are at this time, under reasonable operating conditions, competitive with turboprop and reciprocating-engine aircraft. This is with currently reliable turbojet engines having a specific fuel consumption of between 1.05 and 1.00 lb per lb of thrust per hr. This also applies to aircraft of greater size for ranges up to say, 2000 miles.

As engines under development become sufficiently reliable for civil use in the next four or five years with a specific fuel consumption of 0.9 lb per lb of thrust per hr or less, then the 3000 to 3500 mile transport will be completely practical at an all-up weight of 140,000 or 150,000 lb, propelled by from 36,000 to 42,000 lb of static thrust developed in four

or four to six powerplants. With this arrangement there should be no difficulty at all in meeting all the existing CAA requirements with an ample margin, together with any other reasonable requirements which may emerge as a result of the adoption of the jet transport. Such an aircraft will fly at over 500 mph at a mean altitude of approximately 40,000 ft and will be able to carry reasonable fuel reserves.

2. *Flexibility of Operation*—Investigations carried out by the Technical Department of A. V. Roe Canada Ltd. and borne out by Hetzel[1] indicate that the flexibility of operation of the jet transport can be much greater than is commonly imagined, particularly if four or six engines are adopted. By adjusting the number of engines in use to the stacking altitude, almost complete flexibility can be obtained without penalties in economy. With the developments taking place in engine combustion, the problem of restarting engines at altitude is already well on the way to solution.

3. *Availability of Traffic Control Aids and Techniques*—Very brief experience with a jet transport prototype operated on a public airdrome for test flight purposes while the normal traffic was landing and taking off indicates that the bogey of jet transport operation is nowhere near so serious as was imagined. Changes will undoubtedly be required in airdrome organization when jet transports are extensively used, but for the time being there should be no difficulty at all in mixing jet transport operation with normal reciprocating engine aircraft operation and gaining considerable experience in preparation for the more extensive use of the jet. The holding of jet aircraft is probably nowhere near so serious as people think. We have already had occasion to simulate the condition of a 45-min or 1-hr journey and 1¼ to 1½ hr of stacking at low altitude. With suitable clover-leaf loops at the ends of the main runways on which the aircraft can be loaded and unloaded, the jet transport can be swung onto the take-off runway with a minimum of taxiing time when the clearance for take-off is given. The warmup time for the jet engine is, of course, very short.

For the time being there may be a period where, for the longer ranges, the turboprop has a slight advantage. But in five years, turbojets will be running with fuel consumption figures of the order of 0.9 lb per lb of thrust per hr, and better. Then the advantages of the turbojet aircraft from every point of view will be decisive.

The technical requirements for such an aircraft are pretty well known now. It will comprise a normal circular fuselage of advanced streamline shape with thin wings and probably a moderate degree of sweep back. A high degree of pressurization will be required. The fuselage structure from wings to wind screen will have to be structurally so safe that pressurization failure is as unlikely as a primary wing failure. For high altitude flying, which will increase in volume from now on, suitable methods of gust alleviation will have to be developed for high-speed passenger flight. The high-altitude restarting of engines is already well under way.

In short, the technical background for development of the high speed jet is already available and embodied in the first breed of jet transports. This will be further developed for the 1955–1960 aircraft.

The great potential development of the jet engine ensures that it is the only reasonable assumption for the future. The stimulus already provided by the prototypes now flying will spur on the investigation and development of safety, airworthiness, communication and operation techniques, which the authorities now realize must be ready for the 1955 overseas transport.

[1] See Aero Digest, Vol. 58, No. 6, June, 1949, pp. 42-44, 92: "Emergency Operation of Turbojet Transports," by E. Hetzel.

Airplane Manufacturer's Viewpoint

by Carlos Wood
Preliminary Design Engineer
Douglas Aircraft Co.

DESIGN of the "1955 SAE Transport" must be such that it is usable for trip lengths of from about 830 up to 3500 miles, in order that a production quantity of at least 100 airplanes may be set up. This is necessary in order to lower operating costs into a profitable region. Even more flexibility of operation is desirable if possible.

Although up to 9000-ft length runways may be considered for the 3500-mile operation, the shorter ranges require operations into and out of runways of 5600-ft length or less.

It appears that the 1955 SAE Transport will cost a minimum of $22.5 million through one prototype, but that it may be possible to sell the airplane at the 100 quantity for around $2 million each if the airplane doesn't get too large.

This is concluded from a study based on the assumptions listed in Table 1.

Figs. 4a and 4b result from application of ATA cost equations to domestic and international operations respectively. They coordinate the results with the number of airplanes and the related minimum stage length required in the basic design so the 1949 traffic level could use the number of airplanes set up. Comparison is also made to desired operating cost limits for profitable operation, thus establishing the allowable economic limits of minimum usable stage length (or operating range).

If, as is indicated by study to date, the 1955 SAE Transport is going to be required to operate at short ranges to build up total traffic available, and thus increase the total number of such aircraft in operation, it is obvious that a large part of the operation must be out of and into airports other than the major terminals. Accordingly, a survey was made of present airports served by certificated domestic airlines.

Making the *very* bold assumption that the traffic carried will be in proportion to the number of airports that can be used by the airplane, we can arrive

at a rough idea of the airport lengths required for different amounts of traffic, and therefore the airport lengths required at various trip lengths. Fig. 5 gives such a relationship between airport runway length and stage (or trip) length, together with the number of airplanes to match minimum stage length.

Table 1—Assumptions Made

Maximum Stage Length Needed, miles		3500
Capacity	International Service, passengers	50
	Domestic Service, passengers	58
Weight (Empty), lb		75,000
Utilization, hr per day		10
Passenger Load Factor, %		60
Payload per Passenger, lb		250
Overhead, % of direct operating cost		100

The distribution of passenger travel by stage lengths was assumed to follow the best available estimate for 1948. Cost of constructing the 1955 transport was figured at 1949 cost levels.

Airline Operator's Viewpoint

by H. R. Harris
Vice-President and General Manager
American Overseas Airlines

I feel that somehow we must find ways to focus intensified research upon the human, or public, reactions to being transported in your future airplane.

When an airline operator buys your air transport in 1955, he will have to do it on a basis that he will still be operating it 10 years from that date. From the operator's viewpoint, it has to be an air transport of 1965 that he receives in 1955. What will the public be willing to pay money for in 1965? That is is the question.

Can we build airplanes where the floors don't vibrate, the trays don't vibrate, your bathroom doesn't vibrate, your seat doesn't vibrate?

Not knowing the answer to this question, I merely hazard a guess that the public might find enjoyment in a vibrationless trip.

Can't you design windows that are two or three or four times larger than the present ones?

Is it absolutely necessary, after you have finished your great and tedious experiments in the most modern design of aircraft wings, to place these wings directly in line of vision from the windows, and thereby deprive the window of its intended function—visibility? Or can the wing be out of the way?

Can windows also extend downward from the traditional height of a window ledge—down to the level of passengers' ankles, perhaps, so they can see?

As cabins grow larger, can't we keep them narrow, with two seats on each side of the aisle but with three or four levels if we are to have a transport which carries scores of people? Something mysterious happens when you put a hundred people all in the same cabin. Perhaps research will tell us what it is. Anxieties flare up more quickly in a mob than in a small group. The heaving shoulders and pale green discoloration of one upset passenger reflects in the unconscious reactions of 99 other passengers when they are all together. Putting people on two, three, or four different floors will keep the size of each group down, as well as insure better visibility.

Please do not attempt to design a transport for 1965, 1955, or any other time which costs more per passenger to provide service than previous transports. We are placed in a difficult position if we obtain new aircraft and find that we should charge more per passenger to break even. We in the international business must sell air transportation to people of many other nations, in addition to Americans. We need to have fares become lower and lower to bring air transportation within reach of more and more people.

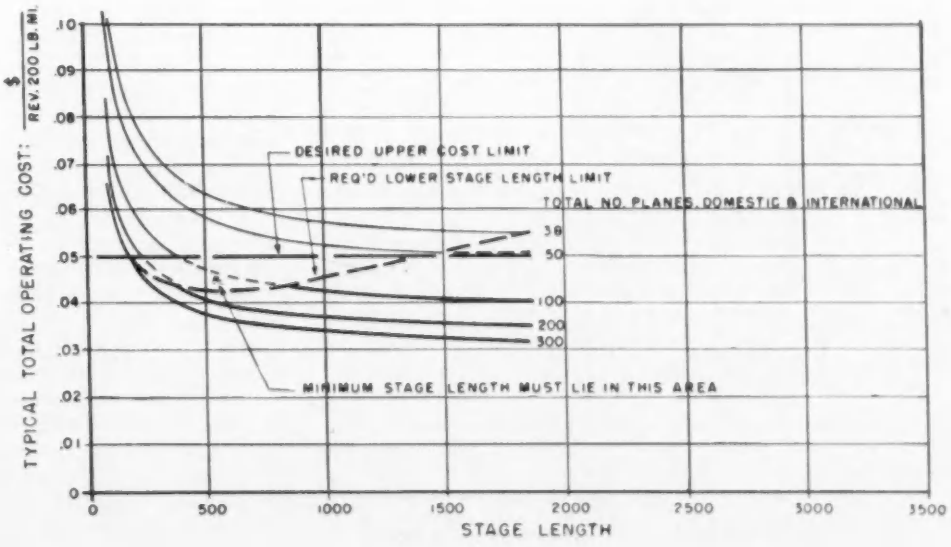


Fig. 4a—Cost versus stage length as function of number of airplanes in domestic use. ("Rev." = revenue)

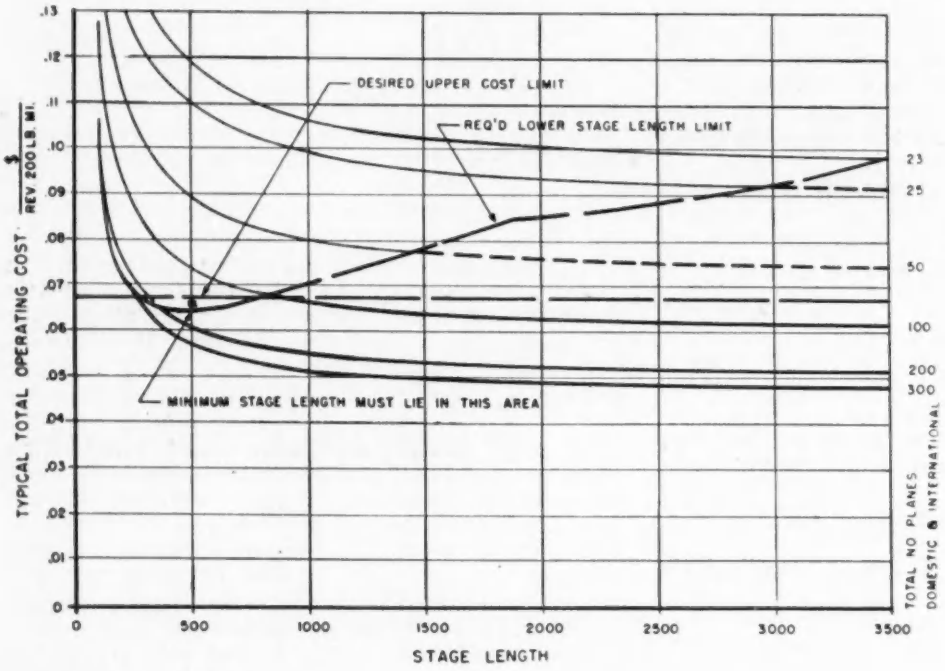


Fig. 4b—Cost versus stage length as function of number of airplanes in international use

Looking ahead to 1965, we suspect that anything that reciprocates, vibrates, and drags along at 400 mph may be quite old fashioned.

I must give you my personal views on the aircraft desired for transocean service in 1955:

It is a low-wing monoplane, providing sleeperette-type seats only for the not more than 50 passengers and carrying 2500 lb of mail and cargo in addition to 150 lb of baggage for each passenger. It must not have an extremely critical center-of-gravity requirement.

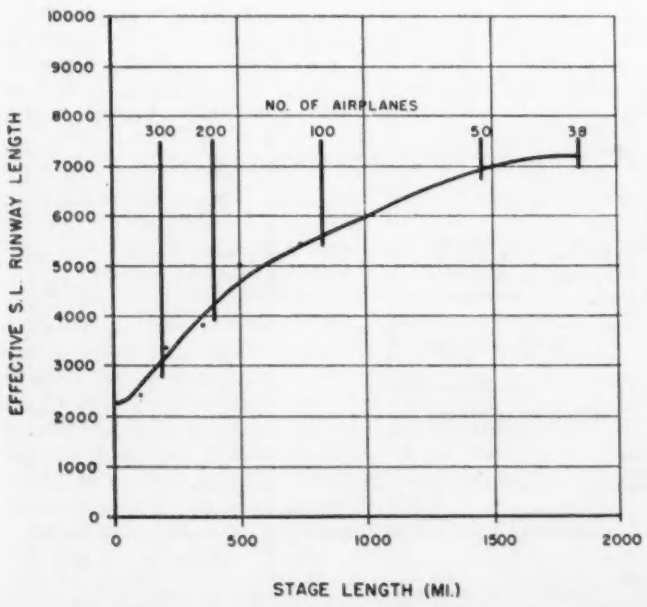


Fig. 5—Effective sea level runway length versus stage length

Although there will be no berths for either passengers or crew, there will be separate toilet facilities for men and women passengers. The lounge will seat 10. The galley has storage and serving space for two meals for a full airplane.

There is plenty of space for coats, hats, and other personal belongings passengers bring, plus space to stow life jackets, pillows, and blankets. Each seat has a separate reading light and cabin attendant call. The public address system can provide canned music.

Cabin altitude does not exceed 8000 ft regardless of flight altitude. The large windows have provision for defrosting. Air exchange is sufficient to permit smoking of pipes and cigars, at least in the lounge. The airplane contains equipment for its air conditioning in the air and on the ground, whether or not main powerplants are operating. Cabin temperature maximum is 80 F and minimum is 65 F, regardless of outside conditions.

Preferably the crew will have three pilots, all of whom are navigators, and two cabin attendants. A flight engineer will be required also if the aircraft has reciprocating engines. The pilots' compartment must be air conditioned. One sleeperette chair will be available in the crew compartment for crew rest.

Pilot-operated radio-telephone will be the only type of communication required.

The airplane will be able to fly nonstop in either direction between New York and London with full load—the faster, the better. It must not require more than 6000 ft for take-off and landing at either airport—taking into account altitude, temperature, humidity, and all other "accountabilities." It must be able to reach an airport from any point en route after loss of 50% power.

The airplane must not be submitted to stacking or to waiting for take-off. Straight-in approach and zero-zero landing are imperative.

Four-Point Program Can Ease Railroad Diesel Engine Pains

EXCERPTS FROM PAPER* BY

R. W. Seniff

Engineer of Tests,
Baltimore and Ohio Railroad Co.

OVERCOMING obstacles to efficient and economical operation of railroad diesel engines—a challenge to operator, engine builder, and refiner—hinges on achievement of these four goals:

1. Maintenance practices that fully exploit the service life built into diesel engines and their parts.
2. Realization of both a uniform fuel oil specification and a balance between fuel quality and maintenance costs.
3. Better lube oil specifications and lubrication practices.
4. Standardization of parts.

Bettering Maintenance

There are some who believe there is more service life in diesel engines than is now being obtained from them. This is based upon a few observations where rate of wear of ring and liner, ring groove, piston pin and piston pin bearing, main and connecting rod bearing has indicated that, under favorable conditions, these parts do not need to be disturbed at the mileage at which railroads usually service them. The problem is: How and to what extent can we capitalize on this potential service life?

As a rule something happens to prevent high mileage between repair jobs which results in the replacement of many parts long before they actually wear out.

Sometimes this stems from the failure of one small part deep in a power assembly where the failure can be described as a design or materials weakness. Sometimes it is caused by fuel or lubricating oil characteristics, or a combination of the two, which causes corrosion, sludge, or lacquer. Such conditions may also be caused by the lack of care the railroad gives these materials while handling or using them. Sometimes early failures result from some minor detail overlooked when repairing engines, or from distrubing engine parts too often by inadequately organized maintenance practices.

In any case, repair costs suffer in two ways: (1) from the initial cost of repairing a premature failure where most of the parts disturbed by the repair work are still in excellent condition; and (2) by the increased deterioration throughout an engine, which frequently accompanies the removal and replacement of even a single cylinder assembly.

Removal and replacement of parts which are still good, no matter how carefully done, frequently induces additional trouble. Perhaps this is caused by simply disturbing parts which have found their optimum running fit and finish. Or, perhaps, it is caused by introducing dirt or water into the lubricating system. For instance, it is difficult to remove a cylinder assembly without disturbing the existing dirt in an engine and causing it to move from a place where it did no harm to one where it causes trouble.

Frequently where one or two cylinder assemblies are removed for the correction of trouble in a single part, new and old parts are mated together. Unless such work is done with great skill and with adequate attention to small details, they refuse to run together. The solution of this problem appears to depend upon the solution of three minor ones.

First, can the railroads improve parts life and secure better economy by planning routine maintenance more closely around periods of complete overhaul?

At the present time, it is customary practice to

* Paper "Operating Problems of Railway Diesel Locomotives" was presented at SAE National Diesel Engine Meeting, St. Louis, Nov. 1, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

overhaul a few cylinder assemblies at a time at maintenance points. Such practice does not readily lend itself to thorough cleaning, inspection, and testing of an engine, either before or after the work is done. Existing dirt in the engine is disturbed and outside dirt or water is frequently introduced. Since dirt is one of the great enemies of diesel engines, thorough cleaning practice and meticulous care in handling of parts is one of the cardinal points of diesel maintenance.

Certainly there comes a time when a diesel engine needs to be lifted out of the locomotive, completely stripped, thoroughly cleaned, carefully inspected throughout, and put back together in as nearly as possible the same condition as that in which it was received from the builder. A long period of trouble-free performance should result from such treatment. To accomplish this, the best overhaul facilities and highly skilled inspectors and mechanics are required. A careful statistical study will probably furnish the answer to this question. However, for this to really pay off, two additional requirements must be satisfied.

The second requirement hinges upon the engine builder's ability to improve certain weaker parts of the engines so their service life will more nearly equal those which have potentially long life. The history of diesel engines in American railroad locomotives clearly shows that parts life has constantly been improved. However, the improvement in the life of the different parts has not progressed at the same rate, with the result that the better potential life of the majority of parts cannot be capitalized upon because of the weakness of others. The old adage, "A chain is no stronger than its weakest link," applies to this situation.

It is very disconcerting to remove a perfect cylinder assembly because some small part down inside could not keep up with the rest of the parts. The railroads themselves can assist in overcoming this costly situation by maintaining in useable form sufficient statistical data concerning life of parts, rate of wear, and cause of failures. These data must really be used as a working tool.

The third problem hinges upon the railroads' ability to maintain within the engines, while they are in service, those conditions which are necessary for long parts life. Recent revelations[1] on wear rates throw sufficient light upon this situation to at least warrant serious consideration. We need more work of this nature and more publication concerning it.

Maintenance of good lubricating oil conditions within the engines is an important step toward good performance. The selection of a good lubricating oil is essential too, but does not insure, good lubricating conditions. Adequate analysis of crank case oil samples at sufficiently frequent intervals on all engines, if properly interpreted and promptly acted upon, can be made to pay good dividends.

Good lubricating oil conditions, suitable fuel

[1] See paper "Rates of Wear in Railroad Diesel Engines," by Ray McBrian and L. C. Atchison, presented at SAE National Diesel Engine Meeting, Nov. 1, 1949.

TEST METHOD	TEST	LIMIT	ASTM 2-D	2	3	4	5	6	7
D-613	CETANE NUMBER	MIN	40	45(40)	46	45	45	50	40-45 50
D-158	I B P °F	MIN	—	—	—	—	370	—	—
D-158	90° BOILING POINT °F	MAX	675	650	625	690	690	—	650
D-158	FINAL BOILING POINT °F	MAX	—	700	675	—	—	—	700
D-158	DISTILLATION RECOVERY %	MIN	—	97.5	98	—	—	—	975
D-129	TOTAL SULPHUR %	MAX	1.0	0.75	0.5	0.5	0.5	1.5	0.5
D-130	CORROSIVE SULPHUR-(MODIFIED-3 HRS @ 212°F)	—	NEG	PASS	PASS	—	—	—	PASS
D-189	CONRADSON CARBON %-(ON 10% BOTTOMS)	MAX	0.35	0.15	0.5	0.5	0.5	0.5	0.15
D-96	WATER & SEDIMENT %	MAX	0.10	0.05	0.05	0.05	0.05	0.10	0.05
D-97	CLOUD POINT °F	MAX	—	TO SUIT	—	—	—	—	10
D-97	POUR POINT °F	MAX	*	TO SUIT	TO SUIT	*	0	0	0
D-93	FLASH POINT °F	MIN	100 OR LEGAL	150	150 OR LEGAL	150	150 OR LEGAL	115	150
D-482	ASH %	MAX	0.02	—	0.02	0.02	0.02	0.02	0.02
D-88	VISCOSITY SSU @ 100°F	—	32/45	—	33 MIN	33/50	35/50	32/70	35/50
—	GASSES OR CORROSIVES	—	—	—	—	FREE	—	—	—
—	CORROSIVES	—	—	—	—	—	NONE	—	—
—	90% BP + CETANE NO	MAX	—	—	—	—	—	—	13
* 10°F BELOW OPERATING TEMPERATURE									

Fig. 1—Comparison of The ASTM D975-49T proposed diesel fuel specification with the specifications of five railroad diesel engine builders (in columns 2 to 6) and the specification of one railroad (column 7)

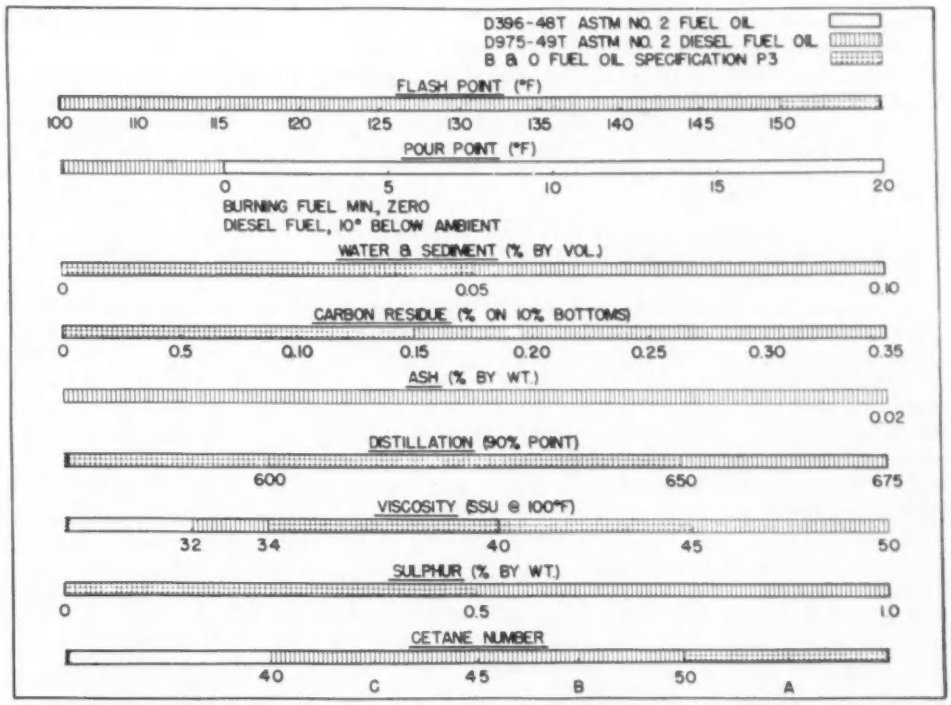

D396-48T ASTM NO. 2 FUEL OIL
D975-49T ASTM NO. 2 DIESEL FUEL OIL
B & O FUEL OIL SPECIFICATION P3
FLASH POINT (°F)
100 110 115 120 125 130 135 140 145 150
POUR POINT (°F)
0 5 10 15 20
BURNING FUEL MIN., ZERO
DIESEL FUEL, 10° BELOW AMBIENT
WATER & SEDIMENT (% BY VOL.)
0 0.05 0.10
CARBON RESIDUE (% ON 10% BOTTOMS)
0 0.5 0.10 0.15 0.20 0.25 0.30 0.35
ASH (% BY WT.)
0.02
DISTILLATION (90% POINT)
600 650 675
VISCOSITY (SSU @ 100°F)
32 34 40 45 50
SULPHUR (% BY WT.)
0 0.5 1.0
CETANE NUMBER
40 C 45 B 50 A

Fig. 2—Comparison of ASTM burner and diesel fuel specifications with the railroad specification shown in column 7 of Fig. 1

careful regulation of engine load, clean engine intake air, and clean and properly serviced engines are conditions essential to long parts life which are entirely in the railroads' hands.

Perhaps we should be satisfied with the savings resulting from the inherent fuel efficiency of diesel engines. But if the railroads wish to gain an extra dividend which comes from a further reduction in maintenance costs, they should examine present maintenance practices with the object of securing longer and more reliable service between overhauls.

The Fuel Problems

Perhaps the greatest problem shaping up before the railroads today is fuel quality. There has been a great deal of talk in the past about the possibility of a shortage of diesel fuel. It now appears that the shortage is not so much one of quantity as it is one of quality. Indications are that from a broad viewpoint, there will be an adequate supply of petroleum fuel for railroad diesels for a long time to come; and when that is gone, an almost unlimited supply can be synthesized from coal.

In the meantime, it appears that railroads will be faced with the necessity of using fuels of unknown performance characteristics so far as railroad service is concerned, unless they can make adequate actual railroad service tests of diesel fuels.

Some railroad people view with apprehension any change in fuel quality. When the first diesel locomotives were placed in service, serious fuel oil troubles developed which led to adoption of increasingly stringent fuel specifications. Thus, early in the history of diesels on American railroads, they arrived at a grade of fuel which gave performance.

It had a carefully controlled distillation range, was very low in sulfur, a cetane number of 50 or slightly higher, a low pour point, good storage stability, and was extremely clean. Its users have come to consider it the ideal railroad diesel fuel. Practically all railroad performance data, maintenance practices, and fuel handling facilities are based upon their experience with it.

The cost of operation and the reliability of the locomotives are the predominant factors in the operation of railroad diesels. Railroads do not wish to jeopardize either one. They actually want to reduce the overall cost without sacrificing anything in reliability. It is believed that the engine builder and oil refiner feel the same way and share the responsibility with the railroads.

One part of that responsibility is to determine the economic balance fuel quality and total cost of operating railroad diesels. Some people believe that any increase in sulfur content of the fuel will increase engine maintenance costs. If savings in cost of fuel offset this, it may be an economically sound step to use higher sulfur fuel as long as reliability is not affected. On the other hand, it is believed that railroads can use a lower cetane fuel without harmful results. How far they can go in that direction is another question.

Fortunately, the CRC 1.0% sulfur-40 cetane railroad diesel fuel tests will help answer these questions. Unfortunately, these tests which got under way this year, are really about three years late because it will require several years to complete them. It is essential that a sufficient number of tests be

made and completed successfully so that the correct deductions can be made from the results.

It also appears essential for all engine builders to participate because it is difficult, if not impossible, to predict long-time over-the-road performance on the basis of relatively short-time laboratory engine tests. The railroads have too much at stake to take a chance on using high sulfur-low cetane fuels until they determine, by thorough service tests, that the overall cost will be satisfactory in all engine types.

The railroads' next need is for one uniform fuel specification for all diesel locomotive engines.

Fig. 1 lists the principal parts of the five existing fuel specifications of five railroad diesel engine builders and one railroad compared with the ASTM D-975-49-T Diesel Fuel Specification. No two specifications are the same throughout. There is not even complete agreement on any one item in these specifications. No doubt similar confusion would be found if all the railroads' diesel fuel specifications were compared.

Engine builders expect purchasers to use specification fuels in their engines at least during the warranty period. This might be easy if a railroad used only one manufacturer's engines. It might be possible if the railroad had a separate fuel tank for each manufacturer's engine. But it is not so easy when a railroad has all five makes of engines and must fuel them from the same supply tanks. Column 7 of Fig. 1 shows how one railroad tries to satisfy them all.

Another interesting thing about this comparison is that the second nearest agreement on any one item in these specifications is on water and sediment. But the irony of it is that modern railroad diesels could not complete a successful run on a fuel having a sediment content of 0.05%. Furthermore, most railroad fuel stations are not designed to remove even 0.025% sediment. Just what would happen if the railroads should suddenly have to use fuel containing the maximum permissible sediment?

Does it not appear that the time has come, in view of the wide acceptance of diesels by railroads, for the railroads, the engine builders, and the oil companies to get toegther for the purpose of writing and maintaining a mutually acceptable railroad fuel oil specification?

Three-Way Attack Urged

The term "mutually" is used because there are three sides to the question. The railroads want low overall operating cost with emphasis on reliability. They want readily available supplies of fuel and they don't want to handle special fuels for special engines. They want either to plan their fuel handling facilities for the fuels the specification describes, or they want a specification which describes a fuel which their existing facilities will handle.

As users of the equipment and handlers of the fuel, railroads have some idea of what they need in fuel characteristics and should therefore take a more active part in formulating uniform fuel specifications. It is logical to assume that the engine builder wants pretty much the same things and especially that he wants to design his engines to burn the widest possible range of fuels. A concrete step in this direction by improved injection was reported by Barth, Robbins and Lafferty.[2]

The oil refiner, on the other hand, is limited by what to pay for fuel, his available crudes, and refining methods. He wants a steady outlet for his fuel because facilities are limited and he needs to plan his allotments months or perhaps years ahead. We can help him considerably if he knows what we want now and what we may be able to burn in the future, as influenced by improvements in engine design, maintenance, and lubrication practices. He can help us by telling what kind of fuel we may expect to get in the future. This will be of value to the railroads in preparing for its handling and use, and to the engine builder in designing engines or improving existing ones to burn it.

Anything which results will be a compromise; but if it results in some standard based on the practical aspects of all three viewpoints, it will be a happier situation than now exists.

The probable immediate result might be a railroad specification based on the ASTM 2-D classification, separated into several restricted sub-classes based on cetane and sulfur. The ultimate goal should be to increase the available supplies and if possible to reduce the cost of railroad diesel fuel by broadening its specifications.

Considers Sulfur Angle

Improvements in fuel handling facilities, engines, engine maintenance, and lubrication practices may become part of this program as it continues to develop. It is possible that the "special heavy-duty type" engine oils may become necessary to offset ill effects of high sulfur fuels and in that connection may actually prove economical. At the same time, the oil companies should be constantly on the alert to develop economical methods of producing low sulfur railroad diesel fuels in anticipation of the possibility that the engine may not tolerate higher sulfur fuel.

Fig. 2 is a graphic comparison of the ASTM burner and diesel fuel specifications and the railroad specification shown in Column 7 of Fig. 1. It gives a somewhat better idea of the specification restrictions applied to ASTM No. 2 burner fuel, ASTM No. 2-D diesel fuel, and railroad diesel fuel and indicates how the railroad specification might be relaxed to increase the supply of railroad diesel fuel.

On some items, such as flash point, it will probably not be practical to go the full range of the D-2 specification. On others, it may become advisable to exceed the D-2 ranges. Any changes from existing railroad fuel quality, however, must be made with great caution and be based upon thorough service testing.

It has been said that the state of knowledge concerning diesel fuels is 10 to 20 years behind that concerning gasoline. It is encouraging, however, that much really scientific work on diesel fuels is being done and published by the builders of smaller diesel engines. This work and its findings can be used to a certain extent as guide for similar studies

[2] See paper "A Railroad Diesel Engine Improvement Based on Study of Combination Phenomena and Diesel Fuel Properties," by H. W. Barth, F. A. Robbins, and H. C. Lafferty, presented at SAE National Tractor and Diesel Engine Meeting, Sept. 7, 1948.

concerning railroad diesel fuels, if the railroads and the industries serving them realize the complexity of the diesel fuel problems and the importance of their solution in the economical operation of dieselized railroads.

Despite of the inherent fuel economy of diesel engines, fuel cost still remains one of the major expenses for railroad operation. In addition to this, diesel fuel quality has a much greater effect upon the cost of maintaining diesel engines than coal quality has upon the cost of maintaining steam engines. Therefore, diesel fuel quality, as well as quantity, is a very significant factor in the success of railroad diesel operation.

Fuels Research Proposed

The answer to the problems of both quantity and quality of fuel will be found in more research shared by the railroads, engine builders, fuel suppliers, and other organizations interested in fuel for the same type of engines in somewhat similar service. The Navy, for instance, falls in this category and it appears important that the needs of this branch of the service should be correlated with those of the railroads.

If the energy and scientific "know-how" of the interested parties can be efficiently coordinated and concentrated upon the vital problems of fuel performance, fuel problems will be solved at much less cost in time and money than if approached in a more or less disorganized manner by individual companies.

The Coordinating Research Council appears to be the logical agency for directing this work. Its methods of operation for such projects are already set up. Some of the best fuel oil chemists and diesel engineers are on its committees working on the numerous and intricate problems which are associated with diesel fuels. Some of these are the groups working on effect of sulfur on diesel engine operation, effect of fuel deterioration (storage stability) on engine performance, ignition quality testing of diesel fuels, front end volatility of diesel fuels, corrosive tendencies of fuels and fuel systems, deposit-forming characteristics, and full-scale test techniques.

The fundamental research now being applied to diesel fuels by the U. S. Bureau of Mines, and which will also be applied to the CRC railroad field service test fuels, could scarcely be obtained through any other channel.

The railroads might be wise to take a look at the large amount of purposeful, well organized research on fuels and lubricants which is being done for their strongest competitors—the small diesel and gasoline engine in highway trucks and buses and the aircraft industry—and wonder if it has anything to do with the success of this competition. Fuels and lubricants constitute such a large proportion of the total cost of diesel operation and have such a marked effect upon the performance of the engines that study of these two items should constitute one of the American railroads' major research projects. This does not seem unreasonable in view of the fact that the fuel alone costs more than the engine.

Railroads operating diesel locomotives from all the different builders cannot economically use different lubricants for similar parts on the different locomotives. A railroad has many servicing points. It must shift its motive power from one location to another to suit traffic requirements. Therefore, there is no assurance that a given locomotive will be serviced at a given point.

The cost of stocking and handling nearly duplicate lubricants at many points and the accompanying danger of mixing incompatible lubricants either while in stock or during the servicing of the locomotive is too great. It is desirable that there be a minimum of lubricant specifications with a maximum range of utility.

For instance, one lubricant for ball and roller bearings in all manufacturers' engines is desirable. It is also desirable that as many lubricant manufacturers as possible be able to supply this lubricant. The same applies to the lubricant for roller journal bearings. If the same lubricant could be used on cars and locomotive roller journal bearings, it would be still more desirable.

The railroads' diesel crankcase lubrication problems exceed any of their previous lubrication problems in technical difficulties, initial cost of lubricant, and in the dollar value of good or poor lubrication practices. They are further complicated by the fact that the effect of lubricant characteristics and fuel characteristics and lubricating practice cannot be separated and must, therefore, be considered as an interrelated problem. The railroads' crankcase lubricating practice could be greatly simplified and the costs reduced if satisfactory, compatible lubricating oils were available from the various oil manufacturers.

Time does not permit going into the "pros and cons" of this problem here, but it is important that the engine builders as a group, their parts suppliers, the oil companies, and the railroads recognize the seriousness of this problem and that they take advantage of every opportunity to simplify it. Because of its complexity, there is a strong tendency to say that it is insurmountable; but its solution holds such promise of economy for the railroads that we should not take this lightly. It is possible that it appears insurmountable largely because no really well-organized, comprehensive, critical, unbiased, approach has been made toward solving it.

Standardization of Parts

There are some parts common to all diesel locomotives to which some measure of standardization could be applied, which would benefit the railroads without particular disadvantage to anyone else. For instance, the dimensions of lubricating oil filter elements and cartridge could just as well be identical for all makes of engines. It would be a boon to the railroads without interfering in any way with competition or progress on the part of filter manufacturers. The same situation applies to fuel oil and possibly air filters.

Interchangeability of trucks and traction motors between certain classes of locomotives of different manufacturer is very desirable.

In short, any part which can be standardized to the extent that it is interchangeable between types and makes of locomotives will improve the efficiency of the railroads, provided it does not interfere with competition or progress.

BASED ON PAPER* BY

H. M. Toomey

Chief, Aircraft Division, First Region,
Civil Aeronautics Administration

THE

CIVIL Aeronautics Administration certification procedures begin with CAA—manufacturer conferences during early stages of a design. They carry on with structural tests; airworthiness tests; engine tests; close contact with construction and assembly of components after fabrication starts; service tests; determination of compliance with Standard Technical Orders; and a meticulous system for reporting, investigating, analyzing, classifying, and correcting malfunction even after the unit is in service. Procedures for certifying large transport-type aircraft are the same as for certifying small two- or four-place craft—though, in the former cases more work is involved and tests are more extensive.

During the early stages of design, CAA engineers confer with the manufacturer or the modifier to help determine the program by which proof of the structure will be demonstrated. Compliance with CAA regulations by structural analysis is accepted only when the structures conform with types for which experience already has shown such methods reliable. Otherwise, substantiation tests are required. Often, portions of structures must be tested—such as control surfaces, control systems, and landing gear shock absorber characteristics. Suitability of questionable design detail or parts also must be established by tests.

The manufacturer's test proposal is reviewed to permit necessary changes in advance. Thus, structural tests will not have to be repeated because of improper application and/or distribution of loads . . . or because of improper arrangement of supports, and so forth. Ground tests are normally required to determine flutter, vibration, and stiffness characteristics.

Manufacturers lacking necessary equipment or personnel are assisted with equipment or personnel by CAA in making ground tests.

Powerplant, propellers, and associated equipment are all required to pass various certification tests to substantiate airworthiness. Outlining the tests, and witnessing and evaluating the data are an important part of CAA engineering activities.

Prior to being certified, an engine must undergo a gruelling 150 hr test run, of which 90 hr are at rated maximum-except-take-off power; 15 hr at cruising power; and 10 hr at take-off power. Other important engine tests include carburetor calibration and a vibration survey.

Because vibration has been a major factor contributing to powerplant malfunctioning, CAA has tried to participate in vibration analyses, and is now equipped to help manufacturers as needed with specialized equipment and personnel. CAA participates also with manufacturers and the military in solution of many other problems, such as those encountered in supercharging, lubrication, reduction gearing, detonation, ignition, stress concentration and reduction, pistons and piston rings, and idling.

Following approval, the drawing of each design component is impressed with the CAA seal and returned to the manufacturer.

After Fabrication Starts

The CAA Manufacturing Inspection Branch stays in close contact with construction and assembly of all components of the airplane after fabrication starts. It is guided both by approved drawings and accepted standards of workmanship.

After tests by manufacturer's pilots have estab-

Facts and Figures

Civil Aeronautics Administration is the executive branch of aviation government. (The Civil Aeronautics Board is a separate, independent agency which operates as the legislative and judicial branch of aviation government.)

CAA employs about 14,000 people. . . . Its appropriation for the 1950 fiscal year is $206,548,605.

It operates through ten regions—seven of which are within the continen-

* Paper "The Civil Aeronautics Administration at Work" was presented at SAE Metropolitan Section, Sept. 15, 1949. Complete paper on which this article is based is available from SAE Special Publications Department. Price 25¢ to members; 50¢ to non-members.

CAA at WORK

lished certain preliminary figures, the CAA Flight Section helps the producer to set up the test program necessary to demonstrate compliance with flight requirements. CAA personnel accompanies practically all flights. Quantitative information is obtained by company pilots, qualitative characteristics by CAA pilots. CAA furnishes photographic equipment to obtain distance required to land and come to a complete stop, assuming a 50 ft obstacle at the end of the field and to obtain the distance required to take off and clear a 50 ft obstacle at the end of the field.

Service Test

An accelerated service test (consisting of a minimum of 75 hr and maximum of 150 hr) follows completion of the certification tests.

Many proposals have been made to change the service test conditions, because it is generally agreed the 150 hr maximum is inadequate to eliminate all the bugs which a modern transport plane may develop after months of service. No definite plan has crystallized to date, but one noteworthy proposal is to place the airplane in scheduled cargo service for a 9 to 12 month period prior to carrying passengers.

Following the accelerated service test, a final Type Certification Board meeting reviews the whole program and, if in order, authorizes a Type Certificate and an Airworthiness Certificate.

Technical Standard Orders

Requirements for approval of components and materials for which specific standards are not contained in the Civil Air Regulations are set forth in Technical Standard Orders.

When he has sufficient technical development data on his product to prove to himself it meets the provisions of the applicable Technical Standard Order, a manufacturer may (1) forward a statement of conformance to that effect to the CAA; and (2) may immediately thereafter make deliveries to customers of the items covered, along with a similar statement. Typical of the items covered by TSO are: smoke detectors, airspeed indicators, climb indicators, automatic pilots, altimeters, fire detectors, life rafts, life preservers, aircraft fabric, airspeed tubes, position light flashers, fire extinguishers, and combustion heaters.

Follow Through

Even after an article is in service, CAA follows through with a meticulous system for reporting, investigating, analyzing, classifying, and correcting malfunctions. Agents located throughout the United States and many other parts of the world will visit the scene of any accident in the shortest possible time to report to CAA in Washington a complete description of the malfunction. There it is coordinated with CAA regions, manufacturers, and operators. Round-the-clock consultation in such cases is not uncommon.

For scheduled airline operators, CAA has developed a daily mechanical hazards report. Every 24 hr, the airline operator reports to the CAA agent-in-charge any mechanical malfunctioning other than of a routine nature. These reports go to Washington and to each CAA region, where they are examined with a view to heading off any repetition of the difficulty. The reports are summarized weekly and monthly by Washington and sent out to all regions and airline operators.

When approached by individuals or companies for advice about the possibilities of new ideas or designs, CAA makes every effort to put the individual concerned in touch with parties who might be interested.

about CAA....

tal U.S.A. The other three are Alaska, Hawaiian Islands, and the International Region with headquarters in Washington, D. C. which deals primarily with foreign air carrier operations.

Offices and personnel are located in London, Paris, Lima, Tokio, Bangkok, Manila, Panama Canal, Buenos Aires, and Rio de Janeiro. Missions made up of CAA technicians operate in 10 foreign countries.

Fig. 1—The difference in deposits on the ring and land area of these diesel engine pistons indicates the detergency characteristics of the two new oil types. Engine from which the piston in "A" was taken ran on regular U. S. Army Specification 2-104B oil; that in "B," on Supplementary List No. 1 oil; and the one in "C," on Supplementary List No. 2 oil

TWO

BASED ON PAPER* BY **William A. Howe**

Chief Fuels and Lubricants Engineer, Bus and Truck Section, Automotive Products Engineering, GULF OIL CORP.

TWO new lube oil types, with considerably increased detergency characteristics, have been established under U. S. Army Specification 2-104B. These new oils are aimed at minimizing both excessive engine deposits and high wear rates induced by high-sulfur diesel fuels as well as reducing deposits from gasoline.

The Ordnance Department defines these high detergency oils as follows:

a. Supplementary List No. 1 (to U. S. Army Specification 2-104B). "The following oils, in addition to meeting all the requirements of U. S. Army Specification 2-104B, have been placed on this supplementary list No. 1 because these oils meet the additional requirements of AXS-1551 procedure modified by use of 1% sulfur fuel. These oils were originally developed for use in diesel engines. Until more data are available, no general statements can be made in regard to the performance of these oils in gasoline engines."

b. Supplementary List No. 2 (to U. S. Army Specification 2-104B). "The following oils, in addition to meeting all the requirements of U. S. Army Specification 2-104B and Supplementary List No. 1, have been placed on this Supplementary List No. 2 because the oils also meet the additional and more severe requirements of the Caterpillar Superior Lubricant Series No. 2. These oils were originally developed for use in diesel engines. Until more data are available, no general statements can be made in regard to the performance of these oils in gasoline engines."

Since there is no adequate measure of detergency, we can compare the detergent characteristics of these oils by assuming that 2-104B oil has basic detergency. Supplementary List No. 1 oils will have

* Paper "Motor Fuels and Lubricants" was presented to the SAE New England Section, Boston, Oct. 11, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

NEW LUBES
Cut Deposits and Wear

twice the detergency of oils meeting the 2-104B specification. And those oils complying with Supplementary List No. 2 requirements have four times the detergency of 2-104B oils.

Fig. 1 illustrates the effect of this added detergency in these two new type oils. Fig. 1A shows a piston from a single-cylinder Caterpillar Engine Test, AXS-1551, using a good regular U. S. Army Specification 2-104B oil and a 1% sulfur fuel. The piston in Fig. 1B was run in the same engine test, but here an oil meeting Supplementary List No. 1 requirements was used. Fig. 1C shows a piston from the Caterpillar single-cylinder 1-D Engine Test procedure which was run in a supercharged engine, using a Supplementary List No. 2 oil.

Differ in Deposit Tendencies

Tests of these three oils show a noticeable difference in piston ring and land area deposits. Of course, both the regular 2-104B and Supplementary List No. 1 oils would not be satisfactory in the 1-D procedure.

While Fig. 1 showed how these high detergent oils alleviated engine deposits when using high sulfur oils, Table 1 reveals the wear characteristics in the same series of tests, with the same oils. This tabulation shows that as detergency increases, wear decreases.

Moving from diesel to gasoline engines, we find that the detergency of regular 2-104B oils is generally believed to be inadequate for effectively reducing deposits from gasoline. This notion stems from the tremendous amount of deposits experienced by the Army in the Zone of the Interior when using regular heavy-duty oils, and also from field experience since the war with commercial fleets and passenger cars. It also is felt that regular heavy-duty oils do little or nothing to minimize cold weather sludge.

The two new heavy-duty oil types show great promise of both minimizing gasoline deposits and greatly reducing the quantity of sludge obtained in cold weather or in low-load operation.

Fig. 2 depicts the effects of the various types of oils on gasoline engine operation from the standpoint of deposits. In Fig. 2A are the pistons and screens from an engine run on regular motor oil after about 9000 miles of service. The pistons and screens in Fig. 2B were taken from an engine that ran about 10,000 miles on premium oil. From an engine operating on U. S. Army Specification 2-104B oil for approximately 9000 miles came the pistons and screen in Fig. 2C. And those in Fig. 2D are

Table 1—Engine Wear Rates with the Three Types of Oils under U. S. Army Specification 2-104B

	AXS-1551*		Caterpillar 1-D Procedure*
	U.S.A. 2-104B Oil	Supplementary List No. 1 Oil	Supplementary List No. 2 (Series 2) Oil
Top Ring Gap	0.022 in.	0.010 in.	0.008 in.
Cylinder Wall—Long.	0.0026 in.	0.0004 in.	0.0003 in.
Cylinder Wall—Trans.	0.0026 in.	0.0003 in.	0.0001 in.

* 1% Sulfur Fuel Used

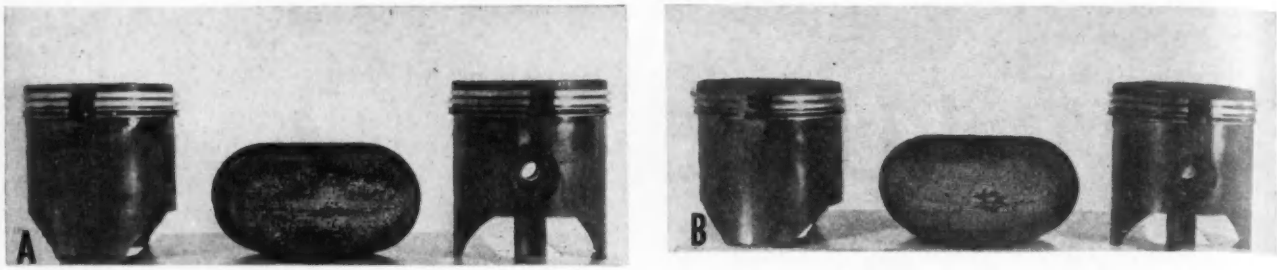
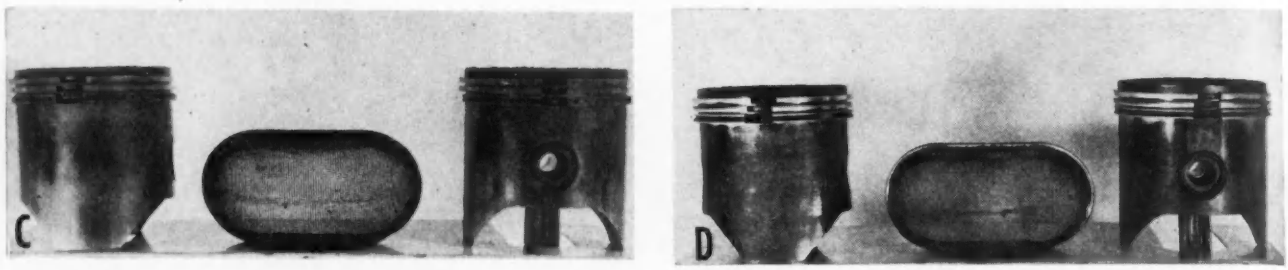


Fig. 2—Type of oil used accounts for a variation in deposits among the pistons and screens from gasoline engines shown here. "A" shows results with a regular motor oil (American Petroleum Institute classification); "B," premium oil; "C," U. S. Army Specification 2-104B oil; and "D," an oil with detergency about halfway between that of Supplementary List No. 1 and Supplementary List No. 2 oils



from an engine than operated some 10,000 miles on an oil which has a detergency about midway between that of Supplementary List No. 1 and Supplementary List No. 2 oils.

All these engines were operated in passenger cars in what may be considered normal passenger car operation.

These tests show that the uninhibited regular type motor oil produces engine deposits in a relatively short period of operation. The pistons and screen from the engine operated on premium oil also had deposits, but not to the extent of those operated on the regular type oil. This leads to the conclusion that deposits from the engine on regular oil are made up of both oil and gasoline deposits, while deposits in the engine operated on premium oil are mainly of the gasoline variety.

Effect of Added Detergency

Additionally, the parts of the engine operated on regular heavy-duty oil seem to show that this type of oil has had little or no effect in reducing the amount of deposits from gasoline. But the parts of the engine operated on the oil containing an extra slug of detergency show little or no deposits, from either the lubricating oil or gasoline, after the same period of operation as the other engines.

It is interesting to note that the other parts of the engines operated on all four oils show corresponding amounts of deposits, and that the engine operated on the oil with the high detergency was very clean throughout, including the bottom of the crankcase. While the parts shown were from single engines, at least 10 engines are operating on each of the four oils, and the parts shown are representative of the other engines examined.

The Ordnance Department's definitions of Supplementary Lists No. 1 and No. 2 emphasizes that no general statement can be made for performance of these oils in gasoline engines. These are precautionary statements, as far as the Army is concerned, since there is little data on performance of these oils, particularly with respect to spark-plug deposits, combustion chamber deposits, and wear. Most of the data which are available indicate that there is little to be feared in this regard from the use of these high detergent oils.

Ash Content High

However, there is one precautionary note relative to these two new oil types, namely on their ash content. While the regular U. S. Army Specification 2-104B oil contains from 0.2 to 0.5% ash, ash content for oils meeting Supplementary List No. 1 will range from 0.75 to 1.5%; and it may be as high as 3.0% in Supplementary List No. 2 oils.

In both gasoline and diesel engines this high ash may raise a problem of combustion chamber deposits. This could be important, particularly in gasoline engines, since excessive combustion chamber deposits will raise the engine's octane requirement. In the new Oldsmobile and Cadillac engines, and any other high compression engines which may follow, excessive combustion chamber deposits and their effect on octane requirements can pose a serious problem.

Antiknock Engine=High C.R. +Low Octane Fuel

EXCERPTS FROM PAPER* BY **Alex Taub** CONSULTING ENGINEER

CONTINUING along the path of boosting fuel octane number is a costly move that would restrict use of American automotive equipment to the area of distribution of this special fuel. High compression ratios can be based on nondetonating engines rather than nondetonating fuel. Engine designs are available to operate with 12 to 1 compression ratio with 80 octane fuel.

We are again at the point of decision. Shall we find antidetonation in the engine or by chemistry? Today there are the urgings that the fuel industry should turn its attentions and efforts to production and distribution of a super-fuel that would permit the use of 12 to 1 compression ratio. The size of this undertaking is not only immense, but it comes at a time when the project must be viewed with concern.

Large investments for production are needed to increase the total supply of fuel. Higher octane fuel would lower the total output and absorb too much investment in the fuel production of the future. The fact to keep in mind is that in general, 65 octane represents the most economical type of fuel to produce.

If it is argued that a change in the fuel would eliminate the necessity for a tooling change for the engine, then we must point out that higher output engines by any means would require greater rigidity than can be obtained by simple tool changes.

"Broad-minded" engines with inherent antiknock ability have been with us for a long time. In 1919 I tested an engine with 9.5 to 1 compression ratio with the fuel available at that time, which probably represented 55 to 60 octane, and without detonation. There have been many engines built and tested over the last 30 years which have operated under elevated compression ratios with ordinary fuel without detonation. Early experience with nondetonating engines came at a time when understanding was lacking; hence the importance of these engines was lost in the shuffle of resistance to change. In some cases it was because of serious mechanical or lubricating difficulties.

In examining the past and the present with an eye to the future, it becomes clear that the internal hot spots, the high temperature of the exhaust valve in particular, must be eliminated or made innocuous to achieve a high degree of mechanical octanes. This, in the past, was a common statement in the industry made with reference to its being something desirable but unattainable. The answer has been with us right along but we all have chosen to ignore it.

It is time to use engine designs that inherently do not have red hot exhaust valve heads inside the combustion chamber. All of the present means of keeping the engines running—tetraethyl lead and alcohol-water injection—should be used to give better protection from a higher level of performance, or be eliminated from the present-day performance requirements.

If our vehicle engines were developed to burn the leanest possible mixture ratio at part throttle, as for instance 21 to 1, equal to 20% less fuel, and we coupled this with 8.5 to 9 to 1 compression ratio, which would improve part throttle fuel consumption 25%, we would have an overall part throttle improvement of 40% with 70 octane fuel. With 11 or 12 to 1 compression ratio using 80 octane fuel and 21 to 1 mixture ratio, we should improve our fuel consumption 45% or more.

Actually nondetonating engines that acquire these virtues by the absence of the hot spots in the combustion chamber are bound to give improved fuel consumption with any kind of driver, because we do not have to provide two extra mixture ratios to quench the hot spots of full throttle to avoid preignition and damage to the engine. This is 16% gain and is the insurance policy against the "heavy-footed driver."

It is important then to study the various types of

* Paper "Mechanical Octanes" was presented at SAE Philadelphia Section, Oct. 25, 1949. (This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

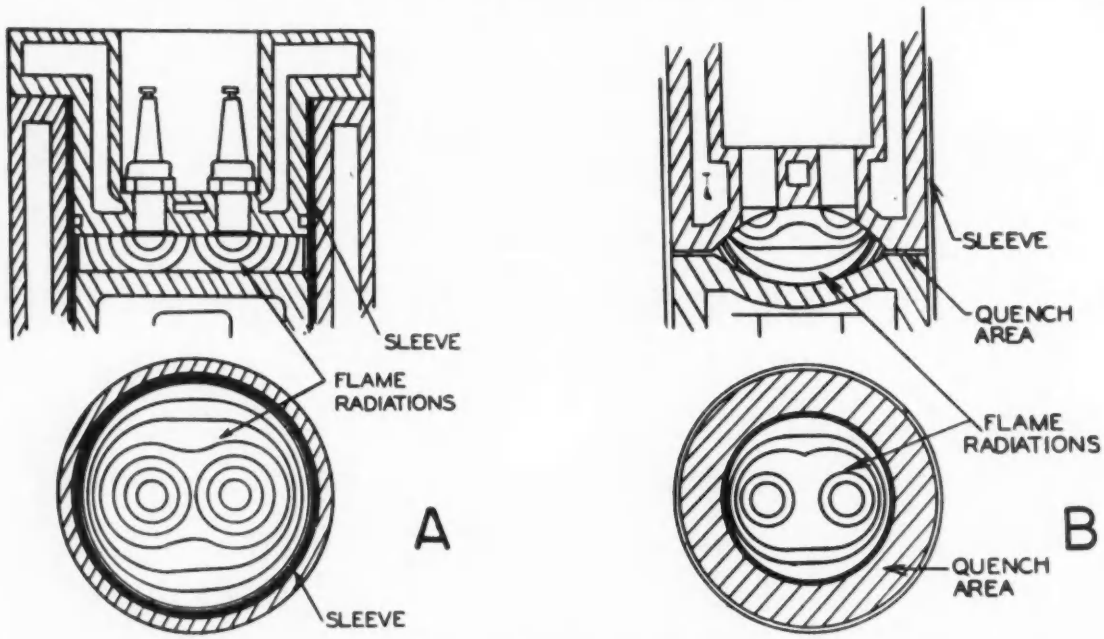


Fig. 1—The typical single-sleeve aviation engine combustion chamber, with two spark plugs, at left in "A," when modified as in "B" at right to provide an antidetonating quench area equal to 30% of the piston, can add 10 engine octane numbers

nondetonating engines and extend their development.

The first design to consider is the Argyle or "Burt" single sleeve. It is particularly important since the functional phases have been given a real trial in aircraft. This engine has been thoroughly developed for air, for materials, lubrication, and cooling. Essentially this type of engine is a liquid-cooled type, although Bristol has a noble execution of an aircooled job in the Centaurus.

The spiral moving sleeve is made of austenitic nitrided steel and slides in an aluminum cylinder barrel, and thus provides a little balance against adverse relative diametral expansion. The hottest part is made of the least expanding material.

Fig. 1A shows a typical single sleeve engine combustion chamber with two spark plugs as required for aviation. The positioning of two plugs in this crowded area for plug durability is a job in itself. However, it has been done and done quite well. Plug cooling is further complicated by the cooling of the head where the natural flow is up and down as well as across. Steam formation is a problem and the use of non-boiling coolants is almost a must.

Fig. 1B shows a modified combustion chamber which would provide an antidetonating quench area of 30% of the piston, which may improve the engine 10 octanes. The main point in favor of this sleeve valve engine is the absence of a red hot exhaust valve.

With the sleeve valve engine and spark plugs near center with a pancake combustion chamber, the rate of pressure rise will be very high and will combine with high pressure to create a high shock condition. This, too, can be modified with an emptical cross-section combustion chamber.

The major problem of the single sleeve valve engine is lubrication and cost. Lubrication of the sleeve under vehicle conditions of 200 F variation in under-hood temperature is a problem which would require considerable work. There has been no recent production experience with this engine for vehicles; but it has, however, a fine record in aviation.

The cost of the drive for the sleeve is considerable as executed by and for aviation. An entirely new design is required to bring these engines into line costwise. They do qualify as antidetonating engines since the combustion chamber hot spots are very much less than in poppet valve engines, thus providing a potential increase in highest useful compression ratio of 3 to 4 ratios. How this advantage is exploited is important.

The split sleeve engine, Fig. 2, is subject to the same potential thermal advantages as the single sleeve engine and the same disadvantage in matters of spark-plug cooling. The split sleeves operate between an inner bore and outer bore and thus it may be more difficult to control lubrication than with the single sleeve. Because the sleeves do not rotate but merely move up and down, the sleeve drive mechanism is simple, even though separate rockers are required for each half sleeve.

This engine can be designed to operate on low octane fuel for relatively high outputs. There is no production experience of any volume behind this engine, and of course no experience with it in any service. If, as, and when this engine is designed for public use it will get a welcome.

The Aspin engine, Fig. 3A, appeared on the British scene somewhere around 1936. The claims for it were, to say the least, buoyant. Aspin believes in horsepower per c-c and exploited his design for speed. This is the engine with the rotating conical

combustion chamber wherein the port in the chamber registers with intake, and exhaust ports, and spark plugs at one-half engine speed. The problems of the Aspin engine are all mechanical. It will run and has run at 14 to 1 compression ratio with 80 octane fuel. It is capable of extremely high volumetric efficiency and its porting and ignition will allow it to run at speeds above 10,000 rpm.

The Aspin engine functionally meets present conditions better than any other engine. It will operate on lower octane fuel than any other engine for a given compression ratio.

The reason for the high nondetonation value of the Aspin is that it has no hot spot in the combustion chamber during the progress of induction, compression, and burning. The exhaust port is cut off, the incoming gas sweeps the entire combustion chamber and top of the piston. Spark plugs are no problem since the plugs are not exposed to the combustion chamber, except during compression and ignition, after which they are cut off from it. Aspin treats his combustion chamber as if it did detonate and provides a very ample quench area.

As shown, the Aspin rotating combustion chamber, which is a cone, is subject to considerable thrust; and if this thrust were not offset, the friction set up would be prohibitive. Hence Aspin provides a heavy thrust bearing to absorb this load. However, it is desirable for sealing purposes that full contact be made by the cone in the head since heat must be dissipated and seals must be maintained.

The Aspin engine must take its place in the thinking of engineers since thermally it does represent so good a solution. Its functional problems must be weighed against its desirable thermal qualities.

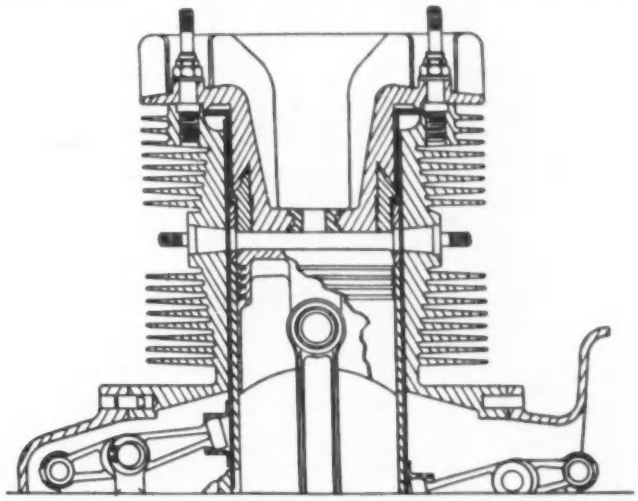


Fig. 2—The split sleeve engine has a potential of relatively high output running on low octane fuel

We might point out that the thrust of the conical combustion chamber can be absorbed by a hydraulic thrust bearing, as in Fig. 3B. Here we have in effect a large hydraulic tappet. The thrust is taken on the oil and the minor leak around the plunger can permit the cone to contact the cylinder head without too much pressure. The cone is provided with an up-and-down freedom or float which keeps the check valve free at times to admit oil. Such a hydraulic thrust bearing can withstand tremendous thrust.

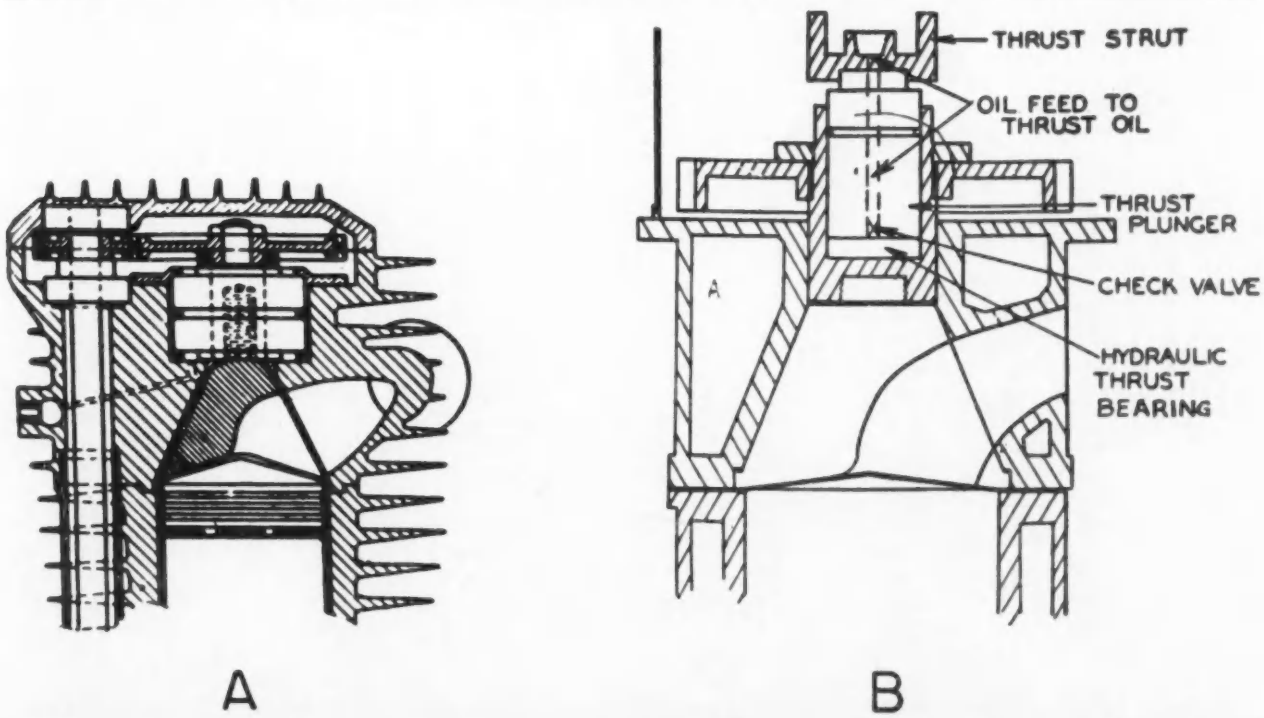


Fig. 3—The British Aspin engine, at left in "A," operates on a lower octane fuel than any other engine for a given compression ratio. To absorb the thrust of its rotating conical combustion chamber, a hydraulic thrust bearing, as shown in "B," can be incorporated into the design

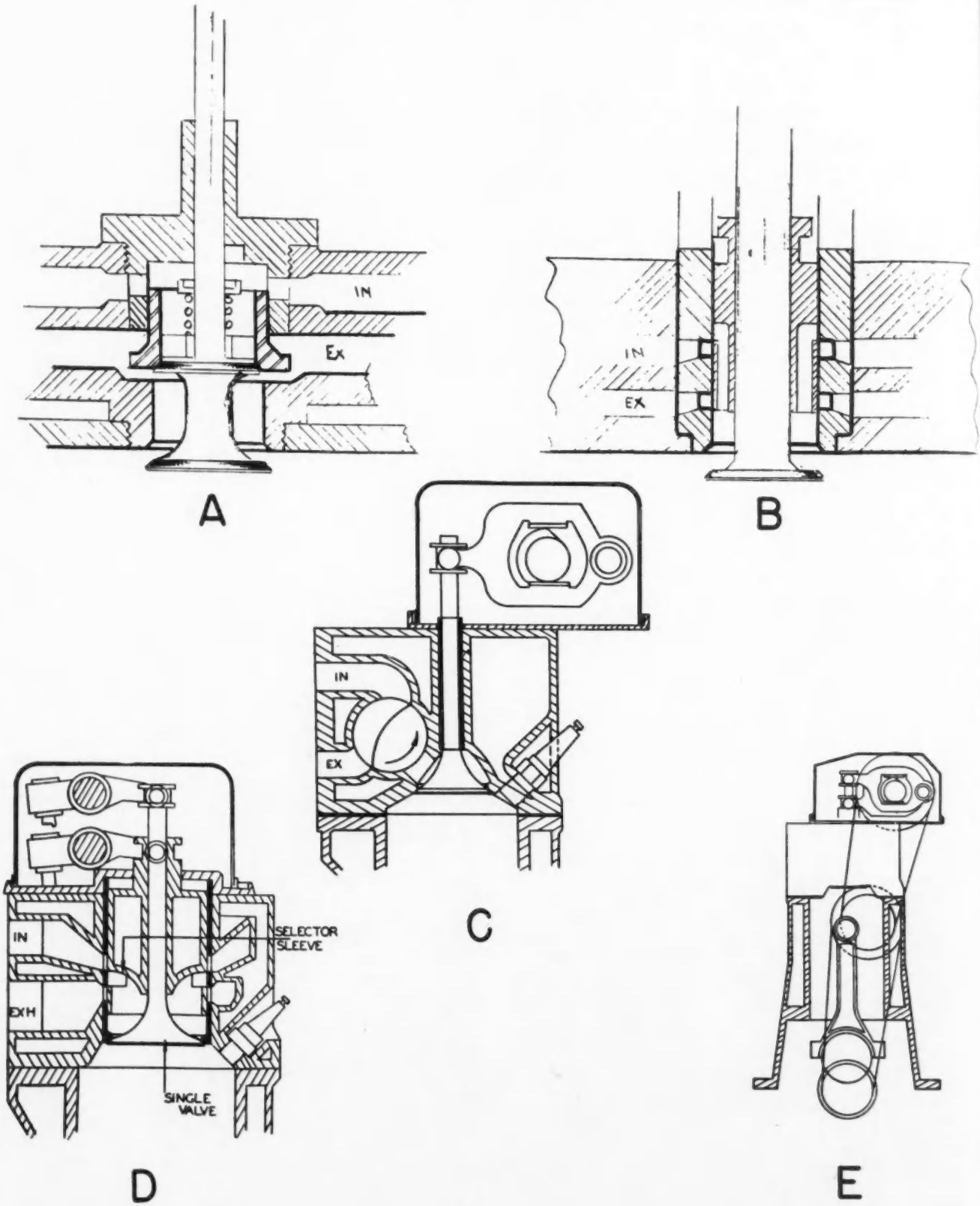


Fig. 4—Various design stages through which the single valve engine has passed. "A" goes back to 1914. Featuring a sleeve behind the valve are "B," of 1930 vintage, and "D," developed in 1938. In 1919 Abell came out with the design in "C," which had a distributing rotor and single poppet valve. The 1949 version of the single valve engine, in "E," has an overhead drive

However, what we need for the next few years is a construction that meets the thermal opportunities without new types of manufacturing techniques or new problems in lubrication. What is needed are:

1. Elimination of the hot exhaust valve.
2. Positive operation of valving.
3. Normal or near-normal cost.

With No. 1 we obtain thermal advantage in lower octane requirements for the highest useful compression ratio. With No. 2 we make progress by eliminating the synchronous valve train that definitely restricts the breathing ability of the engine. High engine speeds may have little commercial advantage; however, engines that pick up speed quickly do have a needed quality for use with automatic transmissions and we would enjoy getting along without tappets. No. 3, near-normal cost, is essential or the engine will have a limited use.

The sleeve valve engines and the Aspin engine meet Nos. 1 and 2; however, they do not meet the required cost picture at all. They do present technical difficulties, and abnormal metallurgy and lubrication is required. They can be good; but each model of each type requires considerable development to bring it to successful use.

We, therefore, believe that the single valve engine meets the majority of our requirements without disturbing the present manufacturing or service techniques.

The single valve has passed through considerable development by an assortment of engineers and development people. Fig. 4 shows various stages and designs. We prefer designs B and D, which include a single valve with a sleeve behind the valve, cooled by incoming gases and not under combustion pressure or heat.

Single valve engines were designed and experimented with in 1913. In 1919 Rollin Abell approached the industry with his design, the original of which is indicated in Fig. 4C. This included a distributing rotor with a single poppet valve, both positively operated. This engine ran in 1919 with the fuel at that time at 9½ to 1 compression ratio.

Due to the valve opening characteristics, in the original tests conducted by the author, 98% maximum torque was obtained at 600 rpm and maximum torque at 2200 rpm. The top horsepower is limited only by port sizes since the speed can be anything the bearing will stand. The distributor was fitted with 0.006 in. clearance, and showed no signs of heat. The valve, of course, was mechanically opened and closed, and proved to be rather simple for initial adjustment. One of the criticisms of the engine at that time was that it would perhaps "idle" badly. In fact, it idled better than standard engines of that time.

The sleeve does not have to be a good fit and up to the present no special means of lubrication has been required. The sleeve is moved by a plain eccentric cam, the valve is moved by a constant dimension cam. Neither require valve springs, both are adjustable in a manner similar to normal valve settings. The sleeve is set for proper opening and closing, the valve is set to just touch valve on seat. From this point on the valve is closed by combustion or compression pressure. The poppet valve stays full open during changeover from exhaust to intake by the sleeve. Intake port opening is rapid because the eccentric is moving through its greatest speed range at this time.

The single valve today gives us sleeve valve operation without the usual faults of such mechanisms —lubrication, metallurgy, and fit. The single valve engine gives us poppet valve ease of adjustment without the hot exhaust valve. The single poppet valve in 720 deg of crank travel is heated by exhaust gas for 220 deg crank travel and cooled by intake gas mixture for 220 deg crank travel. For 280 deg crank travel it is on its seat, during which time it is cut off from the exhaust manifold most of the time.

In a standard poppet valve engine in 720 deg of crank travel, for 220 deg the exhaust valve is heated by exhaust flowing past it; for 500 deg crank travel the valve is on its seat but the back of the valve is exposed to the main exhaust system. With the single valve we have the combined effect of direct cooling by the intake gas with a minimized flow-back of heat to the valve from the exhaust manifold from which it is cut off.

Gains 20 Octane Numbers

It represents a simple approach to the solution of fuel problems. We have estimated over a considerable study period that the lowered temperature of the single valve permits an increase in antidetonation of 25 to 30 octanes in the engine for vehicles. However, assuming that our antidetonation gain is equal to only 20 octane, then this would mean that 65 octane fuel would operate as well as 85 octane in present-day engines.

Experience indicates that we could be certain of 10 to 1 compression ratio with fuel from 78 to 84 octane. With 10 to 1 compression ratio and improved volumetric efficiency, the overall improvement could carry us through the next several years at least. If there is going to be low-priced, high-octane fuel in the distant future, then it would not need to be more than 92. And with the Abell single valve with 92 octane fuel, we should expect 14 to 1 compression ratio in vehicle engines, and to equal the aviation performance with super octane fuel of 300 bmep with supercharged engines.

The removal from the combustion chamber of from 5 to 7 sq in. of 1800 F surface should represent the maximum thermal progress made in engines since the automotive industry began to think.

Fig. 4E shows the single valve with overhead drive. This is a simple layout without the usual fuss and feathers of overhead camshafts. The cost of supporting the shaft on the head is offset by elimination of machining and alignment in the crankcase for a camshaft.

The elimination of tappets, push rods, and push rod covers will pay for the second chain drive that reaches upward to the camshaft. The relative expansion movements of push rod rocker mechanisms are eliminated and the engine will be quieter. The cylinder block becomes simple and suggests fabrication instead of castings, or at least permanent molded aluminum casting with iron cylinder sleeves.

With a little ingenuity in manufacturing we may have an engine as modern as can be at costs equal to present costs, the maximum of mechanical octane, and a minimum requirement of chemical octanes.

Why

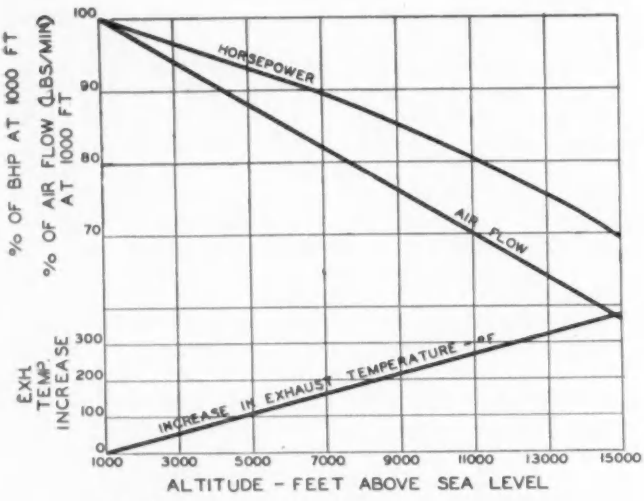


Fig. 1—Effect of altitude on engine performance

SUPERCHARGING is a means of increasing the air capacity of an engine—a means used to obtain more power from given bore and stroke.

Supercharging has been applied to diesel engines chiefly for three reasons:

1. To compensate for decrease in air density at altitudes above sea level so that rated power can be obtained at altitude.

2. To improve power of designs that are inherently bad breathers.

3. To pump extra pounds of increased-pressure air which, burned with more fuel, produce more power.

It can also compensate for loss in air density due to increased intake air temperature or for adverse exhaust back pressure.

Diesel engine designers regard supercharging as one of four logical steps toward increasing rated power of a given engine. The other three are: (1) improving the combustion cycle, (2) maximizing mechanical efficiency, and (3) raising rpm. First step taken is the one which gives the most improvement for the development work expended on it. On this basis, supercharging is usually one of the last.

Power output depends on fuel burned. But merely opening up the fuel pump is not the way to increase power.

Theoretically, 1 lb of an average diesel fuel will burn completely in 14.3 lb of air. If the theoretically correct air-fuel mixture were used in the actual engine, some fuel particles would not engage with their oxygen molecules in the short time available for combustion. Particles not burned by the end of the power stroke would produce soot and smoke. They are wasted fuel because their energy goes to raise final exhaust temperature instead of to produce power.

To increase the chances that each fuel molecule will react with oxygen, excess air—above that needed for the theoretically correct mixture—is provided in the cylinder. Usually the fuel-air ratio is chosen so that at a fixed altitude, normal variations in weather or operating conditions do not affect the horsepower rating seriously.

What happens when an engine designed for near-sea-level operation is run at higher altitudes can be seen from Fig. 1. These data are for a Cummins diesel whose fuel ratio was set at the exhaust-smoke limit at rated altitude. The engine was run at constant rpm and constant fuel flow at various altitudes above sea level. Air consumption decreases uniformly at the rate of 3% by weight per 1000 ft increase in altitude because the air becomes less dense. The engine has fewer pounds of air in the cylinder and available for combustion, even though volume consumption remains practically constant.

Some fuel particles fail to find an oxygen particle with which to unite during the short time available for useful combustion. Such fuel particles do not produce power, so total power falls off as the power curve indicates. Instead, the particles form soot and smoke, and their heat raises exhaust gas temperature as the temperature curve shows.

To achieve efficient, smoke- and soot-free combustion, fuel flow must be cut back at the same rate as weight of air available to the engine decreases.

In numerous cases where the altitude-decreased power output of a diesel engine design is inadequate for its job, supercharging has been applied to the design. The supercharger is geared to pump a sufficient volume of the less dense air at the higher altitudes to supply the engine with the same weight of air the engine consumes with natural aspiration at rated altitude.

Because of faulty design, some diesel engines have inefficient or inadequate induction systems.

How this reduces power output from the potential power available with a better induction system can be seen from Fig. 2. These data were determined on a Cummins diesel engine with air-fuel ratio set to the exhaust-smoke limit—that is, maximum power—at 5.5 in. of H_2O depression at the air intake. With rpm and fuel rate constant, the load (and consequently the power output) was varied as the inlet depression (intake restriction) was increased.

As the airflow curve shows, increasing the intake

Supercharge Diesels?

BASED ON PAPER* BY

Neville M. Reiners

Research Laboratory Manager
Cummins Engine Co., Inc.

restriction "stretches" or expands the air, reducing its density. This decreases the air available per minute to the engine. As a result, horsepower drops and exhaust gas temperature rises.

Tests on both naturally aspirated and supercharged engines indicate the same general effect, but to different degrees. The magnitude of the difference depends on the suction efficiency of the naturally aspirated engine as compared to the supercharged, when equipped with their respective systems. Actual tests show supercharged engines to be less sensitive to restriction than naturally aspirated engines.

The tests demonstrate the importance of designing and properly maintaining air cleaner, suction pipe, intake manifold, cylinder head passages, ports, valves, and valve overlap.

The story of how the Cummins Engine Co. raised the rating of their basic Model H automotive diesel engine from 115 to 300 hp illustrates how supercharging is sometimes used to increase power of a given design—as one of the later steps in the sequence of improvements.

When the engine was introduced, it was rated at 115 hp at 1800 rpm. Successive improvements in the fuel system bettered combustion, and mechanical refinement lengthened engine life, making possible uprating first to 125 hp at 1800 rpm, then to 150 hp at 1800 rpm. For the second jump, combustion and fuel systems were refined to such an extent that any further gains in that direction would entail long-term and expensive research.

Still operators wanted more power. So Cummins added supercharging to bring output to 200 hp at 1800 rpm.

Then three steps were taken simultaneously. Speed was raised to 2100 rpm, piston diameter was increased to 5.125 from 4.875 in., and breathing was improved. These increases in speed and piston size alone would have brought a 27% potential increase in power, for a total 254 hp. The combination of the three improvements raised output to 275 hp.

Now development work leading to more efficient utilization of the augmented airflow has just enabled the company to rate the supercharged engine at 300 hp at 2100 rpm.

Cummins chose a directly connected Roots-type, positive-displacement supercharger because its delivery matches the air need of the engine over the speed range, it is not too sensitive to back pressure, its mechanical construction is simple, and it is reliable. Unfortunately, its efficiency is only about 58%.

The supercharger must always be tailored to the engine's actual air requirements. Otherwise supercharger demand horsepower will be unduly large.

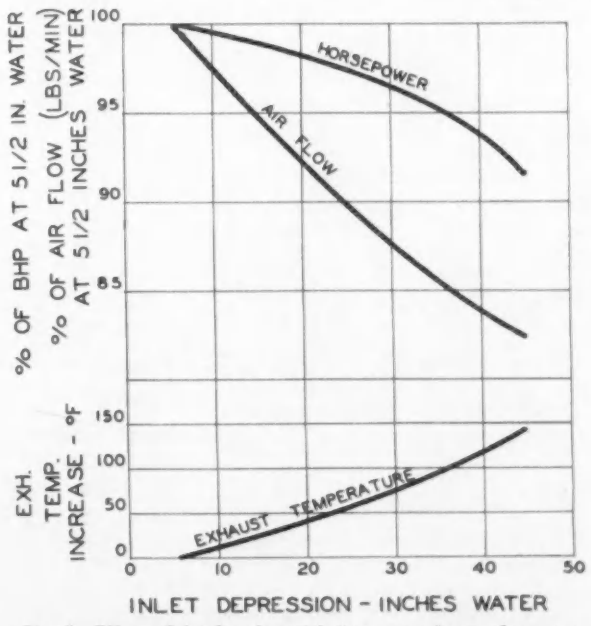


Fig. 2—Effect of intake air restriction on engine performance

* Paper "Why Supercharge?" was presented at SAE National West Coast Meeting. Portland, Ore., Aug. 16, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

SAE National PASSENGER CAR, BODY

March 14-16

Book-Cadillac Hotel, Detroit

TUESDAY, March 14

9:30 a.m.

L. A. DANSE, Chairman

Symposium — Disposal of Industry's Waste Materials, Decreasing Waste, Increasing Salvageability

Controlling Plating Department Wastes
—D. E. BLOODGOOD, Purdue University

Disposal of Acid Wastes
—J. E. COOPER, Ford Motor Co.

Removal of Soluble Oils from Waste Water
—C. W. HATHAWAY, Chevrolet Motor Div., General Motors Corp.

Smoke Abatement
—L. C. McCABE, Air Pollution Section, Bureau of Mines

(Sponsored by Engineering Materials Activity)

2:00 p.m.

J. C. WIDMAN, Chairman

Coordination of Engineering and Materials Handling in the Fisher Body Division of General Motors Corp.
—E. R. FROST, Fisher Body, Div., General Motors Corp.

Recent Developments in Automobile Glass
—G. B. WATKINS, Libbey-Owens-Ford Glass Co.

(Sponsored by Body Activity)

8:00 p.m.

G. M. BUEHRIG, Chairman

Will the Four-Passenger, Shorter-Wheelbase Car Find a Better Place in the American Market?
—J. H. WELLS, The Austin Motor Co., Ltd. (England)

(Sponsored by Body Activity)

WEDNESDAY, March 15 PRODUCTION CLINIC

Joseph Geschelin, General Chairman

10:00 a.m. to 12 NOON—2:00 to 4:00 p.m.

Materials Handling

Panel Leader, O. E. JOHNSON, Kaiser-Frazer Corp.

Panel Members: J. G. ANDERSON, Cadillac Motor Car Div., General Motors Corp., C. H. HUNTOON, Lewis-Shepard Products, Inc., D. W. KELSEY, Union Steel Products Co., O. A. PARMENTER, Parmenter Steel and Conveyor Co., E. B. THURSTON, Houghton Elevator Co., J. C. WEBB, J. B. Webb Co.

(Sponsored by Production Activity)

Gear Design and Production

Panel Leader, R. P. LEWIS, Spicer Manufacturing Div., Dana Corp.

Panel Members: B. F. BREGI, National Broach and Machine Co., M. D. ELLIOTT, Dodge Div., Chrysler Corp., BAIN GRIFFITH, Chevrolet — Gear and Axle Div., General Motors Corp., F. E. McMULLEN, Gleason Works, G. H. SANBORN, The Fellows Gear Shaper Co., D. T. SICKLESTEEL, Detroit Gear Div., Borg-Warner Corp.

(Sponsored by Production Activity)

Production and Manufacturing Control

Panel Leader, C. A. KOEPKE, Consultant

Panel Members: J. E. ADAMS, White Motor Co., F. E. BOZE, Delco-Remy Div., General Motors Corp., E. F. GIBIAN, Thompson Products, Inc., P. A. MILLER, Leece-Neville Co., G. S. WILCOX, Plymouth Div., Chrysler Corp.

(Sponsored by Production Activity)

Preventive Maintenance of Plant Equipment

Panel Leader, H. E. HARDENBROOK, Buick Motor Div., General Motors Corp.

Panel Members: W. C. HARTLEY, Nash-Kelvinator Corp., OTTO KLAUSMEYER, Studebaker Corp., J. E. REHM, International Harvester Co., O. A. WILLIAMS, Ford Motor Co., H. A. ZANNOTH, Cadillac Motor Car Div., General Motors Corp.

(Sponsored by Production Activity)

& PRODUCTION MEETING

Eight separate informal gatherings to exchange information and experience on vital production problems. Each will be sparked by a panel of experts as follows:

10:00 a.m. to 12 Noon

Inspection and Quality Control

Panel Leader, J. N. BERRETTONI, Dr. J. N. Berrettoni and Associates

Panel Members: R. H. COLVIN, Burd Piston Ring Co., G. K. PEETS, Packard Motor Car Co., JAMES RAYER, Timken-Detroit Axle Co., GEORGE SCRANTON, Ford Motor Co., S. C. STARNAMAN, Oldsmobile Div., General Motors Corp., KEITH VAN KIRK, Magnaflux Corp., W. H. VANN, Pontiac Motor Div., General Motors Corp.

(Sponsored by Production Activity)

Steel Heat Treating

Panel Leader, E. H. STILWILL, Dodge Div., Chrysler Corp.

Panel Members: E. O. DIXON, Ladish Co., H. B. OSBORN, JR., The Ohio Crankshaft Co., W. E. PETERSON, Gorham Tool Co., L. E. WEBB, Clark Equipment Co., C. M. CAMPBELL, Chevrolet-Transmission Div., General Motors Corp.

(Sponsored by Engineering Materials Activity)

2:00 to 4:00 p.m.

Surface Finish

Panel Leader, A. F. UNDERWOOD, Research Laboratories Div., General Motors Corp.

Panel Members: E. J. ABBOTT, Physicists Research Co., CHARLES AUGEY, Ford Motor Co., H. J. GRIFFING, Norton Co., C. R. LEWIS, Chrysler Corp., F. R. McFARLAND, Packard Motor Car Co.

(Sponsored by Production Activity)

Body Steel

Panel Leader, N. E. ROTHENTHALER, Ford Motor Co.

Panel Members: W. A. GRAF, The Budd Co., A. P. LUCAS, Bethlehem Steel Co., H. C. SMITH, Great Lakes Steel Corp., W. WEIRS, SR., Fisher Body Central Engineering, General Motors Corp.

(Sponsored by Engineering Materials Activity)

Wednesday Evening

8:00 p.m.

LLOYD WITHROW, Chairman

Elements of Internal Combustion Engine Power

—W. E. LAY, University of Michigan

Cylinder Performance — Compression Ratio, and Mechanical Octane Number Effects

—S. D. HERON and A. E. FELT, Ethyl Corp.

(Sponsored by Passenger Car Activity)

THURSDAY, March 16

9:30 a.m.

H. E. CHURCHILL, Chairman

Suspension Symposium

Wheel Hop and Shake Characteristics in Front Suspensions

—C. A. TEA, Ford Motor Co.

Ride Problems Caused by Secondary Vibrations of Rear Suspensions

—V. D. POLHEMUS, General Motors Corp.

(Sponsored by Passenger Car Activity)

2:00 p.m.

B. E. HOUSE, Chairman

Passenger Car Brake Developments

The Versatile Shoe Brake

—C. R. LUPTON, Bendix Products Div., Bendix Aviation Corp.

What Have Disc Brakes to Offer?

—W. R.RODGER, Chrysler Corp.

(Sponsored by Passenger Car Activity)

DINNER

6:30 p.m.

A. C. HAZARD
Chairman, SAE Detroit Section

Toastmaster, HARVEY CAMPBELL
Executive Vice-president, Detroit Board of Commerce

JAMES C. ZEDER
SAE President

Principal Speaker
DEL S. HARDER
Vice-President—Manufacturing, Ford Motor Co.

Added Feature: General Motors Business Girls Chorus under the direction of Eduard Ossko

CALENDAR

Baltimore—Feb. 9

Dinner preceding inspection of Bendix Radio Plant, Towson, Md.

Buffalo—Feb. 21

Park Lane Restaurant; dinner 7:00 p.m. Meeting 8:00 p.m. Cathodic Protection as Related to Marine Heat Exchangers—Hiram Walker, staff engineer, Harrison Division, GMC. Talk will be illustrated and samples of heat exchanger equipment will be on display.

Central Illinois—Feb. 27

Jefferson Hotel, Peoria, Ill.; dinner 6:30 p.m. Member meeting. Heat Treatment of Gears—Roy F. Kern. Le Tourneau Field Testing Experience—Dan Heiple. Sugar Industry in Hawaii —J. Johnson. After dinner speaker to be announced.

Chicago—Feb. 14

Knickerbocker Hotel, Chicago, Ill.; dinner 6:45 p.m. Meeting 8:00 p.m. Subject to be announced. Speaker: J. M. Davies, dicector of research, Caterpillar Tractor Co., Peoria, Ill. Social half-hour 6:15 p.m. (Sponsored by Donaldson Co., Inc.; Rockford Clutch Div., Borg-Warner Corp. and Perfect Circle Corp.).

Colorado Group—Feb. 21

Pacific Intermountain Express Terminal; tour of facilities 8:00 p.m. Speaker: R. F. Allyne, maintenance manager, Pacific Intermountain Express.

Dayton—Feb. 15

Van Cleve Hotel, Dayton, O.; dinner 7:00 p.m. Meeting 8:00 p.m. Speaker: Russell Kaufman, project engineer, Transmission Div., Chevrolet Motor Div., GMC. Topic to be announced.

Detroit—Feb. 6, Feb. 20 and Feb. 27

Feb. 6—Small Auditorium, Rackham Educational Memorial; meeting 8:00 p.m. Aircraft Turbo-Jet Engines—Robert L. Wells, Westinghouse Electric Corp. A colored movie, The McDonnell Banshee, will be presented.

Feb. 20—Small Auditorium, Rackham Educational Memorial; meeting 8:00 p.m. Panel Meeting on Automotive Steering Today and Tomorrow. Speakers: H. R. Fortgang, Chevrolet Division, GMC; O. R. Rittenhouse, Saginaw Steering Gear Division, GMC; Chester Wisniewski, Lincoln Mercury Division, Ford Motor Co. Social hour will follow meeting.

Feb. 27—Large Auditorium, Rackham Educational Memorial; dinner 6:30 p.m. The Engineer's Place in the Automotive Body Field—J. J. Cronin, general manager, Fisher Body Division, and vice-president, General Motors Corp. There will be entertainment at the dinner.

Indiana—Feb. 9

Antlers Hotel, Indianapolis, Ind.; dinner 7:00 p.m. Automotive Brakes—Design and Test Considerations—R. A. Goepfrich, assistant chief engineer, Bendix Products Division, Bendix Aviation Corp., South Bend, Ind.

Metropolitan—Feb. 16

Statler Hotel; meeting 7:45 p.m. Practical Potentialities of Diesel Engine—C. R. Maxwell, Caterpillar Tractor Co.

New England—Feb. 7 and March 7

Feb. 7—M. I. T. Graduate House, Cambridge, Mass.; dinner 6:30 p.m. Transportation and Maintenance. Speaker to be announced. After coffee speaker: Harry Stanton, Automotive Editor.

March 7—M. I. T. Graduate House, Cambridge, Mass.; dinner 6:30 p.m. Passenger Car. Speaker to be announced. After coffee speaker: Harry Stanton, Automotive Editor.

Philadelphia—Feb. 8

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.; dinner 6:30 p.m. Principles of Truck Leasing—Raymond A. Munder, vice-president and general manager, Yellow Rental, Inc.

Pittsburgh—Feb. 28

Mellon Institute, Webster Hall Hotel; dinner 6:30 p.m. Foreign Automotive Engineering Developments—George A. Round, chief automotive engineer, Socony-Vacuum Oil Co., New York City.

Wichita—Feb. 16

The Polar Bear; dinner 6:30 p.m. Joint meeting with I.A.S. The Automobile—Moving People Through the Air—Prof. Kenneth E. Razak, University of Wichita. Motion pictures.

Williamsport Group—Feb. 6

Anglers Club. Water Manifolds—Prof. Paul Schweitzer, Pennsylvania State College.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
PASSENGER CAR, BODY, and PRODUCTION	March 14-16	Book-Cadillac, Detroit
AERONAUTIC and Aircraft Engineering Display	April 17-20	Statler, New York
SUMMER	June 4-9	French Lick Springs, French Lick, Ind.
WEST COAST	August 14-16	Biltmore Los Angeles, Calif.
TRACTOR	Sept. 11-14	Schroeder Milwaukee, Wis.
AERONAUTIC and Aircraft Engineering Display	Sept. 27-30	Biltmore Los Angeles, Calif.
TRANSPORTATION	Oct. 16-18	Statler, New York
DIESEL ENGINE	Nov. 2-3	Knickerbocker Chicago, Ill.
FUELS and LUBRICANTS	Nov. 9-10	Mayo Tulsa, Oklahoma

Annual Meeting

Continued from page 21

ance; too much power is wasteful in both initial outlay and operating expenses.

Aircraft and automotive engineers are keeping pace with the stiffer service demands being made of their machines. Redesigned components, rearranged systems, and new materials are achieving these more rigid criteria, meeting participants showed.

Various materials are being put to work in mufflers to repel the life-shortening corrosive action of engine exhaust gases. Among those mentioned at the meeting are terne plate, aluminized steel, zinc grip, hot-dipped plating, and porcelain coatings.

One muffler man justified terne or lead-coated steel mufflers where exhaust condensation is serious and where severe weather conditions, rather than extreme exhaust heat, take their toll. Bonded aluminum coatings were said to withstand temperatures up to 1500 F. But since aluminized steel costs twice as much as mild steel, heavier gages of mild steel probably are more economical than lighter gages of the costlier material.

Zinc grip, a galvanized sheet much like terne plate, resists rust and weather for long periods, but pits and breaks down after extended exposure to heat. A muffler specialist said it does not lend itself to welding.

Proper material selection also stood high on the list of gasket engineering aims.

Piston ring and cylinder wear problems were shown to be giving way to materials innovations as well as design ingenuity. Greatest scuff resistance was reported for a thread finish on chrome-plated piston rings. However, if the slight penalty on initial oil economy incurred by this design cannot be tolerated, a smooth finish is used.

A marriage of design and materials also has been effected in top compression rings. Wide rings are desirable from the standpoint of abrasive resistance, while narrow top compression rings impart good scuff resistance. In some cases these conflicting requirements are satisfied by cutting grooves in the ring face to interrupt the continuity of metallic surfaces, and filling these grooves with magnetic iron oxide (Ferrox) bonded with sodium silicate.

A trend toward fewer compression rings for diesels also was noted at the meeting. Good performance with three and even two compression rings has been reported by several diesel engine makers. And experimental use of two oil rings in a common groove has given excellent early results.

Air conditioning discussions emphasized systems design, with the vapor compression system claimed to be the best available for comfort-cooling automotive vehicles.

The adsorption system, capable of operating on engine cooling system heat, was said to be too bulky and heavy for commercial vehicles. A third refrigerating system, the air cycle, has too low a coefficient of performance, about 12 hp per ton. However, it has been revived in recent years as a lightweight system for aircraft.

Upon designers rather than materials men falls the onus for improved brake drum performance, according to reports at the meeting. At least for the present, high carbon cast irons fulfill braking surface requirements better than any known alloy.

No way was seen for reducing brake lining characteristics to some simple index number. Best method of establishing a basis of judgment, it dedeveloped, is to correlate road test data with characteristics determined from samples.

More certain solutions to rigid service demands have been found for high-altitude performance of aircraft oil systems. An oil tank pressurizing valve was said to offer a quick and simple method of improving conventional oil system performance for flights up to 35,000 ft, provided the engine crankcase also is pressurized.

Closed circuit and hot tank oil systems also were shown to better high altitude performance over conventional oil systems. Most desirable for high-altitude aircraft, the closed circuit system rapidly decreases oil aeration with increasing altitude up to 40,000 ft.

However, engineers viewed these systems as only temporary measures since the gadgetry they require leaves much to be desired. By the same token they ruled out additives and antifoam agents since this calls for a special oil; and military operators foresee supply problems in case of war.

Much more rapid realization was seen for remotely-driven accessories than for engine-contained oil systems. In fact, one engineer predicted that within five years all cargo and bomber airplanes will feature remotely-driven accessories.

Another system redesign job was described in the case of the full vacuum-controlled ignition system for motor vehicles. Chief change from the conventional set-up here consists of using a single spark-advance actuating force at the distributor. It is a vacuum diaphragm controlling the breaker plate position, which is actuated by a controlled differential vacuum derived from the carburetor through specially drilled orifices, interconnected in the carburetor body.

Size and placement of these orifices determine the relationship of vacuums produced for various speeds and loads, so that differential vacuums produced are a function of engine speed and load conditions. For this reason, the carburetor must be engineered to meet the requirements of a specific engine. While this new ignition system calls for introduction of additional vacuum passages into the carburetor, it was said that this inconvenience in design and manufacture is far outweighed by the operational advantages of the system.

Several ignition men felt this limitation—adapting both carburetor and distributor design to each specific engine—would make for limited use of the full vacuum-controlled system. However, fears of

system malfunction from gumming of carburetor orifices in operation have not been realized, its designer said, largely because of the air flow through the carburetor.

Car body stylists said they are striving for greater functional design and sales appeal by applying engineering thinking to their work. One stylist adheres to three basic principles in creating his designs: (1) keep weight to a minimum; (2) provide the best visibility possible; and (3) make the car look fast, even when stationary.

He also cited certain empirical formulas, found from experience, for achieving public acceptance of a car, or any other industrial product. They all hinge on the most advanced, yet acceptable design or "maya" stage, as a departure from the established product appearance norm, that the consumer will accept. That "maya" design he defined as one which will meet with resistance from no more than 30% of the market.

For functional truck design from an engineering rather than an appearance standpoint, a simple method was proposed for predicting vehicle performance. This easy-to-use method enables both designer and operator to determine rolling resistance, air resistance, and chassis friction. The total of these three resistances, in terms of horsepower, together with the power required for a given gradeability at a given road speed, tells how much engine a specific operation requires.

JET ENGINE

Installation, Operation Obstacles Are Surmounted

Based on discussions and three papers presented at one Air Transport session and one Aircraft Powerplant session. . . . "The Avro C-102 Jetliner," by **J. C. Floyd**, A. V. Roe Canada, Ltd. . . . "Ground and Flight Evaluation of the Performance of Jet Powerplant Installations and Some Installation Factors Affecting Output," by **William Wahl** and **M. A. Sulkin**, North American Aviation, Inc. . . . "Designing Turboprop Controls," by **C. P. Knapp**, Propeller Division, Curtiss-Wright Corp. . . . **These papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

WHILE turbine-engine enthusiasts left unsettled the question of turbojets versus turboprops for air transports, they did reveal that progress is being made in solving the installation problems of both types.

Reports of the successful results of flight tests on the A. V. Roe Canada Ltd. Jetliner interested all the designers present—although some remained unconvinced of the superiority of turbojets. Both sides found encouragement in reports that accurate means of ground and in-flight thrust determination is uncovering the secrets of efficient turbojet installations and that simple turboprop controls are being perfected.

Avro's Jetliner has made about 30 test flights since its first hop on August 10, 1949 and is now well on the way to completing the tests required for CAA approval, it was announced by one of its designers. The pilot's official report says, "The aircraft has behaved magnificently and is a very easy aircraft to fly."

These tests have proved that some critics of jet-powered aircraft had grossly overestimated take-off and landing runs, the designer related. The Jetliner has repeatedly taken off at weights up to 57,000 lb gross in distances of 1000 to 1500 ft and landed again in about the same distance. In one case, with landing weight about average, the Jetliner stopped less than 950 ft from the approach end of the runway.

The Canadians have discovered also that gusts impose higher forces but for shorter times because the airplane is traveling through the gusts faster. They do not consider gusts more serious than with conventional aircraft. Nor are there any violent airplane maneuvers associated with restarting a jet engine in flight, they find. The Jetliner's Derwents have never required a second try to restart in flight.

Avro believes that transports will be jet powered ultimately and feels it economically unwise to go to turboprops as an intermediate step.

Audience reaction made it clear that some of the U. S. members of the aircraft fraternity agree with the Canadians on turbojets, some do not. But whichever way the decision goes, installation designers will have a backlog of know-how being built up now with military aircraft, a powerplant session indicated.

One company described a simple way they use to make in-flight determinations of turbojet thrust. First they measure static thrust on the ground. (This can be done with strain gages attached to restraining links making the landing gear fast to the ground or, better still, with the new thrust stand at Muroc Air Force Base.) At the same time, they measure exhaust gas total pressure and temperature with a survey rake located in the tailpipe nozzle. From this data they calculate thrust. Then, by

comparing measured thrust with calculated thrust, they obtain a calibration factor.

For in-flight determinations, they collect temperature and pressure data, calculate thrust, and apply the calibration factor.

Experience has taught them that turbojets are more seriously affected by induction system losses than reciprocating powerplants are. Besides, efficiency varies widely with cooling-airflow and ejection characteristics of installations. Static thrust calibrations of one turbojet installation showed the combined effects of cooling airflow and ejection to add about 1% to the rated thrust output. Another installation wasted 10% of rated thrust.

These observations drew from an ejector expert in the audience three tips on ejector design:

1. Don't draw more cooling airflow than just enough to cool the engine at its highest-temperature condition.
2. Keep the mixing length short—that is, one-half to three-quarters of the nozzle diameter.
3. Aim to get the ratio of ejector exit area to nozzle exit area up to about 1.2—surely not less than 1.15.

For cases where turboprops are preferred, indications were that easy-to-operate, safe engine controls will be available.

One type of control system, which conforms to current military requirements for coordinated power controls, was described as incorporating a "condition" lever and a "power" lever in the pilot's quadrant. The condition lever has five settings: (1) stop, (2) start, (3) ground idle, (4) operation idle, and (5) combat and land.

The power control reacts differently for each setting of the condition lever. For example, if the condition lever is set for operation idle, motion of the power lever can vary rpm over the range from 80 to 100% of maximum rpm and can vary power from some predetermined minimum to the rated maximum. If the condition lever is set for start, the power lever can vary rpm from 0 to 60% of the maximum and can vary power from 0 part way up the range.

Between this control quadrant and the engine is a control which translates the pilot's demands for power into fuel flow and propeller pitch setting—with due consideration for such factors as temperature limits of turbine blades and the rpm limit of the gearbox, the speaker explained.

In his control, rpm is governed by an isochronous, Woodward-type governor operating on fuel flow. Temperature, torque, and thrust requirements—whichever happens to be most critical under existing operating conditions—are met by blade angle adjustment. Reason given for this arrangement is that it permits simultaneous control of rpm and thrust, which is sometimes desirable, without resort to thrustmeters—which are not presently available. Besides, near the zero-thrust blade angle, rpm cannot be controlled by a propeller governor.

A competitor revealed adoption of the opposite system: rpm is tied to propeller blade pitch, as in reciprocating engine control systems, and the other variables to be controlled are tied to fuel flow. Reason given for this arrangement is that it can take advantage of previous experience with propeller governors and with regulating fuel flow by carburetors. The same discusser showed, too, that control can be accomplished with only one lever on the pilot's quandrant.

Engineers Strive for Better Use of MATERIALS

LET'S make better use of the materials we have, as well as seek better materials, chorused materials experts in varied fields.

The way to get more out of present materials, they showed, is to:

1. Learn more about the operating conditions to which a material will be subjected.
2. Examine the characteristics of all the available materials.
3. Select the best material, taking into consideration availability and cost.

As for future advances, they held out hope for ceramals for turbine blading and nodular iron for cast parts.

Designers of aircraft turbine engines were urged

Based on discussions and eight presented at one Transportation and Maintenance session, one Aircraft Powerplant session, and two Engineering Materials sessions. . . . "Brakes, and Brake Lining Characteristics," by **J. G. Oetzel**, Warner Electric Brake Mfg. Co. . . . "Review of NACA Research on Materials for Gas Turbine Blades," by **G. M. Ault** and **G. C. Deutsch**, National Advisory Committee for Aeronautics. . . . "Reduction in the Use of Strategic Materials in Turbojets," by **J. M. Pederson**, General Electric Co. . . . "Gaskets as Engineering Materials," by **J. P. Wilson**, Ford Motor Co. . . . "Fibre Board Products Used in Automotive Production," by **J. W. Greig**, Woodall Industries, Inc. . . . "Automotive Brake Lining Materials," by **A. J. Carter**, Chrysler Corp. . . . "Brake Drum Materials," by **F. J. Walls**, International Nickel Co., Lnc. . . . "Nodular Cast Iron," **Gosta Vennerholm, H. Bogart**, and **R. Melmoth**, Ford Motor Co. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

Mrs. Harry L. Horning presenting the 1948 Horning Memorial Award to T. A. Boyd, General Motors Research Laboratories Division consultant, Wednesday afternoon, Jan. 11. Looking on is Albert J. Blackwood, assistant director, Standard Oil Development Co., chairman of the Horning Memorial Award Committee. Boyd received the Award in recognition of "distinguished active service in the field of mutual adaptation of fuels and engines"

to find out more about such operating conditions as temperature gradients, thermal shock, and vibraiton—off-design as well as design conditions. This is the first step in determining whether or not critical materials can be replaced by substitutes.

Scarcity Rating System

For comparing relative criticalness of materials, one metallurgist proposed a numerical rating system. For a purely hypothetical example, he rated relative scarcity of nickel as 1, tungsten 19, cobalt 15, columbium 20 and chromium 5—which numbers he dubbed Element Index Numbers. Then he derived Alloy Index Numbers by summing the products of the percent of each critical element in an alloy and its Element Index Number. Similarly, he explained, Engine Component Index numbers are derived by multiplying component weight by Alloy Index Number. Finally whole engines can be rated and compared.

Speaker and discussers emphasized that these element scarcity ratings were assumed just to illustrate the method. But, they indicated, the figures they have to use for real cases may not be much closer to the true picture because no official estimates of relative availability are issued. They urged the military services to take on this job. Whatever indexes are used, they stressed, should reflect availability during wartime.

Eventually, substitute materials may include ceramals—sintered combinations of ceramic and metal—an NACA review of blade material research suggested. Investigators revealed that titanium carbide ceramals, among others, appear to have considerable promise.

Cobalt, tungsten, and molybdenum were the metallic additions tried. Cobalt-bearing ceramals exhibited exceptional strength up to 2000 F but negligible strength at 2400 F. Tungsten and molybdenum compositions showed only moderate strength at 1600 and 2000 F but surpassed the cobalt at 2400 F.

Study of oxidation characteristics of the titanium carbide ceramals proved that all would require external protection. Cobalt-bearing ceramals were best, but discussers felt that oxidation protection of these ceramals should be achieved by coating, that cobalt was too scarce to count on for this purpose.

Just as high temperatures are the bane of turbine blades, brake experts realized that heat causes many of their problems. Brakes are a means of converting kinetic energy into heat energy, they reminded each other. Although brakes should be heat dissipators, they are actually heat reservoirs during rapid stops.

Brake temperature depends on amount and distribution of lining coverage, deformation of parts, and ability of parts facing the exposed working surface to absorb the heat radiated inward from the shoe. Actual brake lining surface temperatures are always higher than measured temperatures, which must be taken in inner layers, it was pointed out.

Braking Conditions

Operating conditions to consider, other than temperature, are pressures and energy rates. According to one designer, pressures vary from 50 to 425 psi. Energy rates for passenger cars are normally 0.4 to 0.6 kw per sq in. but may exceed 1 kw per sq in. in high-speed stops. Energy rates for trucks are normally 0.7 to 1 kw per sq in. and may reach 2 kw per sq in. in high-speed stops.

On the basis of these operating conditions, speakers and discussers compiled a number of qualities to look for in proposed brake drums: (1) high thermal conductivity, (2) high specific heat, (3) high melting or softening point, (4) high emissivity factor, (5) low coefficient of thermal expansion, (6) high heat capacity per unit volume, (7) high coefficient of friction, (8) low density, and (9) low modulus of elasticity.

No single metal possesses all these attributes. The combination of a cast-iron friction face bonded

to an outer ring of steel seems to be the best approach to the ideal brake drum material, it was said.

Qualities mentioned as essential to good brake lining materials included: (1) correct coefficient of friction—with minimum change with temperature, age, and subjection to water, oil, or grease; (2) durability; (3) relative freedom from tendency to score drums; (4) quietness of operation; (5) non-offensive odor; and (6) suitability for bonding.

First users' report made public on nodular cast iron indicated that, at least from one foundry's experience, this new material offers no immediate economic advantage over present malleable iron castings, except possibly for section sizes larger than those now possible with malleable iron. Competition with gray irons will be solely on the basis of improved engineering properties, except where it is cheaper than alloy irons now used. Use of nodular iron will probably be limited to cases where its superior castability and machinability offset its greater cost.

Body engineers learned that, in designing for fiberboard, the most important operating condition to consider is presence of moisture. Fiberboard tends to absorb moisture, which interferes with dimensional stability. The moisture needn't be leakage; fiberboard is sensitive even to humidity changes.

New Specs Previewed

Existing fiberboard specifications the speaker deemed insufficient. He praised efforts of a committee now working to classify fiberboards by their qualities for the convenience of design engineers.

Gasket manufacturers, recognizing that such operating conditions as exposure to heat, water, or oil should influence selection of gasket materials, are also working on a specifications list. At the time of the meeting, it was before both ASTM and SAE for acceptance, one of its writers revealed.

The specification classifies materials according to composition, and resistance to temperature, oil, and fuel, he explained. Each material has an identification number, which indicates its capabilities in these respects. Tables detail other physical properties.

Process Development Eases New Methods into PRODUCTION

Based on a paper "Process Development—The Link Between Engineering and Manufacturing," by **R. J. Emmert**, General Motors Corp. . . . presented at the Production session. . . . **This paper will appear in abridged or digest form in a forthcoming issue of SAE Journal, and if approved by Readers Committees will appear in full in SAE Quarterly Transactions.**

PROVING and improving new manufacturing methods for their easy assimilation into production has yielded General Motors better, yet less costly parts. The process development section that handles this work made possible production economies in shot blasting and nut welding, with gains in sight on polishing and painting innovations, according to the engineering head of the group.

Because introduction of new production methods poses shop problems and because of human resistance to change, General Motors has found it more economical to develop new methods on a pilot line basis.

Typical of the many methods improved by process development are the shot peening and blasting operations discussed at the meeting. Large amounts of shot were being used in peening highly-stressed parts to increase their life. While the problem as initially framed was to find ways for using cast-iron shot more effectively, it turned into one of finding a new material that would not break up readily and could be reused many times.

Cut-wire shot was said to be the answer. In cleaning castings, cut-wire shot reduced shot consumption 49% and reduced cleaning cost per part by more than 16%. One plant used 1300 lb of cast-iron chilled shot every day in peening front wheel springs. Only 74 lb of cut-wire shot did the same job. Steel shot has increased the average life of springs from 700,000 cycles to 4,500,000 cycles.

In another case, attaching nuts to sheet metal proved to be a production bottleneck. Special nuts costing as much as $11.00 per 1000 were considered. Aim here was to develop a way of welding common square nuts which cost only $2.30 per 1000.

Modifying punch and die, to produce projected dimples on the sheet metal, and designing a welding fixture to locate the nut made it possible to resistance-weld common square nuts in production.

In final development is the tub method of polishing and buffing, described as a procedure for uniformly polishing irregular parts such as those on grilles and bumpers prior to chrome plating. In this set-up, all surfaces of the part are presented

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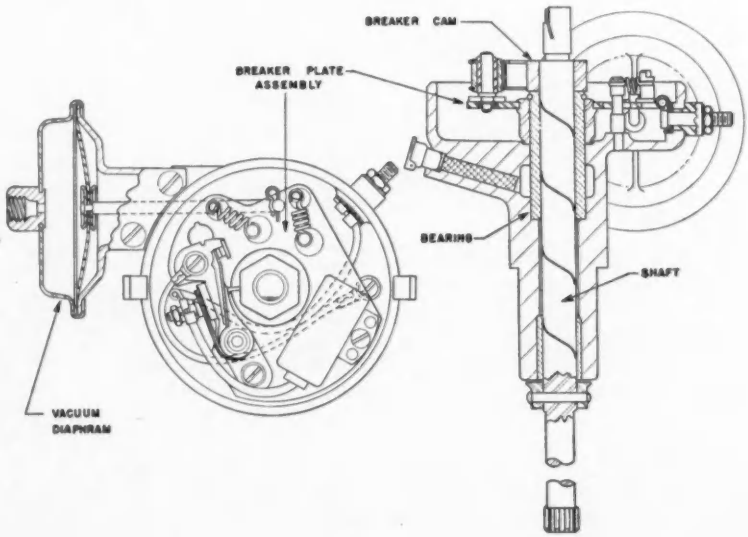
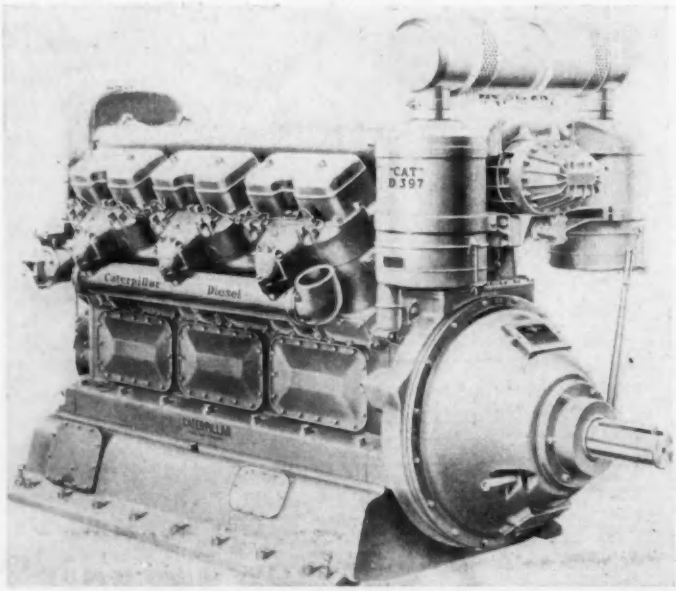
Among New Designs*

AVRO JETLINER, built by A. V. Roe of Canada, is powered by four Derwent turbojets, developing 14,400 lb of thrust at sea level. It cruises at more than 450 mph at 30,000 ft and 60,000 lb gross weight. To date, this civil jet transport has shown desirable operational features, passenger appeal, and higher block-to-block speeds.



FORD'S FULL VACUUM-CONTROLLED IGNITION SYSTEM uses one instead of two spark advance mechanisms. Construction of the distributor, shown at right, is simplified since centrifugal weights are eliminated. Differential vacuum from the carburetor actuates a vacuum diaphragm in the distributor that controls the breaker plate position.



CATERPILLAR'S SUPERCHARGED DIESELS are built in both 8- and 12-cyl models. The engines are 60-deg V type, four-stroke cycle, and have a 5¾-in. bore, 8-in. stroke, and 16 to 1 compression ratio. The 8-cyl model weighs 8550 lb and develops 335 hp at 1200 rpm. The 1100-lb 12-cyl model produces 500 hp at 1200 rpm. The model at left is for industrial use. Other applications are in marine work, municipal powerplants, power shovels, and oil fields.

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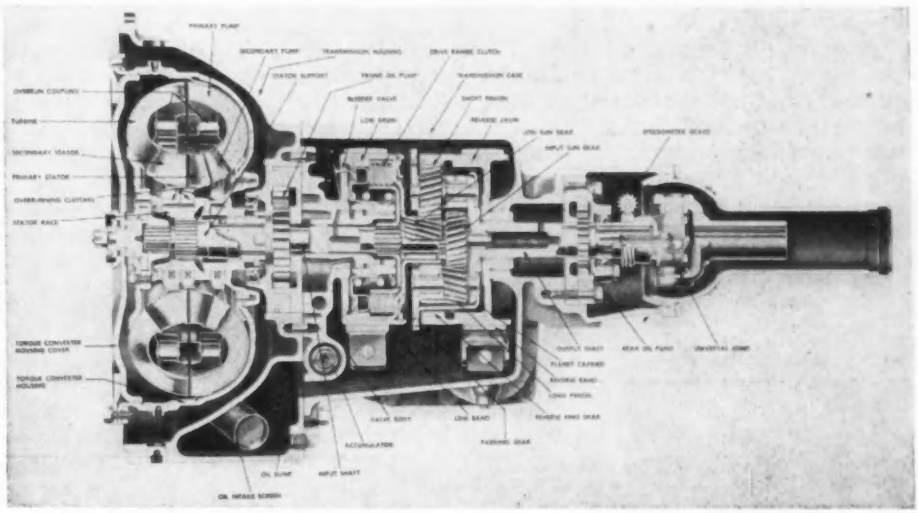
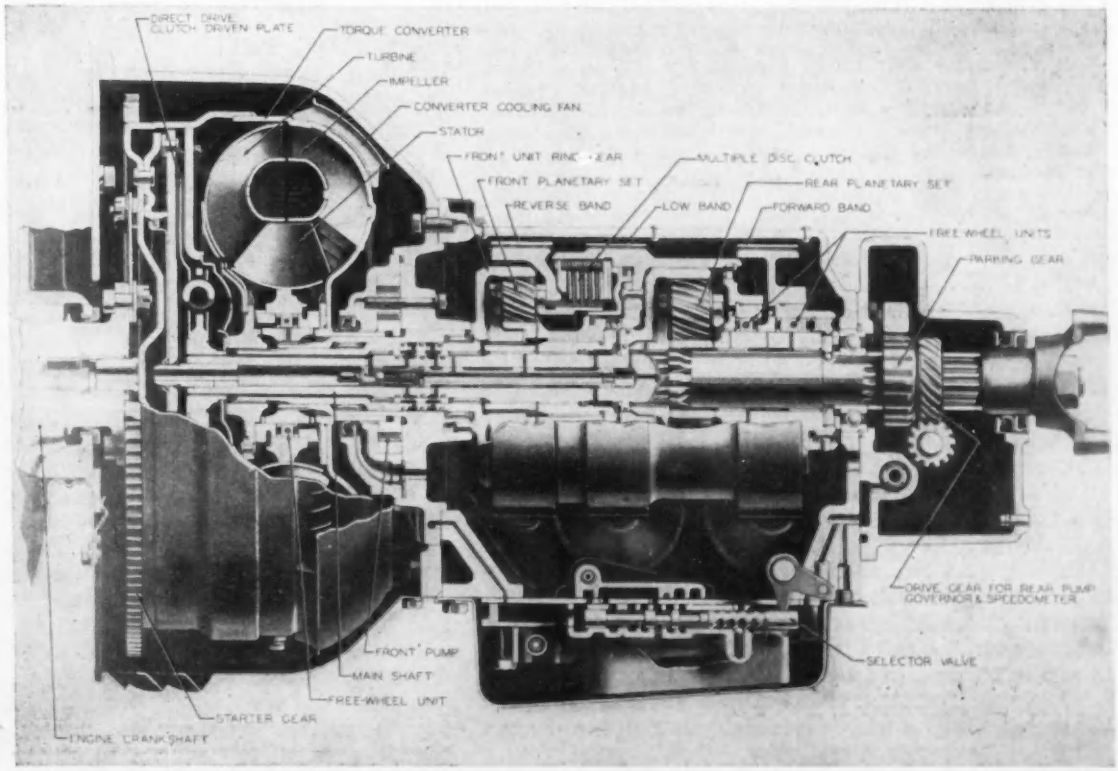
* Based on discussions and five papers presented at one Diesel Engine session, one Air Transport session, one Passenger Car session, and one Truck and Bus session. . . . "The New Caterpillar Supercharged Diesel Engine," by **J. H. Gill** and **R. S. Frank**, Caterpillar Tractor Co. . . . "The Avro C-102 Jetliner," by **J. C. Floyd**, A. V. Roe Canada, Ltd. . . . "The Studebaker Automatic Transmission," by **H. E. Churchill**, Studebaker Corp. . . . "The Chevrolet Automatic Transmission," by **R. S. Plexico** and **R. E. Kaufman**, Chevrolet Motor Division, GMC . . . "Full Vacuum Controlled Ignition System," by **C. W. Rainey**, Ford Motor Co. . . . **All these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

Described at the Meeting

CHEVROLET'S AUTOMATIC TRANSMISSION patterns the General Motors polyphase five unit torque converter, supplemented by a planetary gear set actuated by a multiple disc clutch and two bands to get a driving range, low, and reverse. An effective drive for starting the engine by pushing the engine and improved over-run braking when coasting against the engine are achieved by using an auxiliary fluid coupling. This additional coupling is located inside the converter torus.



STUDEBAKER'S AUTOMATIC TRANSMISSION combines three forward speeds (low, intermediate, and direct) with a three-unit torque converter. The converter is locked out in direct drive, which eliminates slip losses. Two geared forward ratios in conjunction with the converter and direct drive are said to give this transmission desirable hill-climbing ability and down-hill engine braking. A no-creep device built into the transmission obviates need for stepping on the brake pedal when waiting for a red traffic light, and also automatically brakes the car on up-grades, with engine in gear and operating, without brake application.



Continued from page 63

to action of a slightly abrasive material, called mud, in a revolving tub.

Another experimental job under way involves putting a negative charge on paint globules as they emerge from the spray gun, so they will be attracted to the part being painted. While the idea is highly intriguing, its problems are tough. For example, it was said that "the paint globules are not choosey as to where they go, as long as the destination is grounded. So they go to the sides of the paint booth, the roof, the floor, the conveyor, and even back to the spray booth itself."

While these and other difficulties have to be worked out, potential gains make it worth the effort. The method covers twice as many parts per gallon of paint, covers areas better, coats the part completely, and reduces labor costs.

DESIGN TECHNIQUES

Geared to Satisfy Physical, Legal Laws

Based on discussions and six papers presented at one Aircraft session, one Tractor and Farm Machinery session, one Aircraft Powerplant session and one Body Activity session and Detroit Section Junior Activity session. . . . "Fatigue Life of Aircraft Engine Mounting Components," by **R. C. Henshaw, Leon Wallerstein, Jr.**, and **S. J. Zand**, Lord Mfg. Co. . . . "The Effect of Environment on Design Criteria of Helicopter Transmissions," by **Dietrich W. Botstiber**, Piasecki Helicopter Corp. . . . "Soil-Vehicle Mobility Relationship," by **P. W. Woodring**, Engineering Research and Development Laboratories, U. S. Corps of Engineers, Fort Belvoir. . . . "Relationship Between Soil and a Vehicle," by **Major M. G. Bekker**, Department of National Defence, Canada. . . . "Heat Requirement for Ice Prevention on Gas-Heated Propellers," by **V. H. Gray**, National Advisory Committee for Aeronautics. . . . "Functional Approach to Body Design," by **John Najjar**, Ford Motor Co.; **L. L. Anderson**, Chrysler Corp.; **H. R. Pacific**, Ford Motor Co.; and **G. P. Gaulien**, Fisher Body Division, GMC . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

COMPLIANCE with laws—both man-made and nature's—bridges the gap between conception and final realization of a design, ground vehicle and aircraft engineers showed at the meeting. Initial step in the design process, they said, is to find the prevailing laws for operation of the particular component or assembly, whether it is a helicopter transmission, military vehicle, heated propeller, car body, or aircraft engine mounting. Equally as tough is the translation of these phenomena into a workable design.

Helicopter transmissions are a case in point. For example, an oil with about the viscosity of SAE 30, generally acceptable for temperate zone operation, becomes stiff or solid in the helicopter transmission in arctic service.

Tropical conditions were shown to lead to overheating problems which generally affect the design criteria of every transmission component.

Behavior of natural phenomenon as regards vehicle traction and flotation, especially for military and farm machines, was revealed as much more elusive.

The long-accepted ground pressure concept (which embraces only the area on which the load is acting) proved to be false. This came to light from an experience with an experimental vehicle which exerted about 2 psi ground pressure and performed exceptionally well in swamps and heavy soils, while a standard vehicle with a 1.2-psi ground pressure bogged down.

When asked at the meeting to explain this paradox, the military man who cited it replied that in tests performed with loaded steel plates, moved horizontally, shearing resistance of snow increases with load. This test work revealed that low ground pressures offer little shear resistance, thus low tractive effort.

Similar studies exploded other orthodox vehicle traction ideas. For example, a shallow grouser projecting from the track will shear the ground in the same way as a deep one, if the soil is homogeneous. That's why tractive effort per ton of vehicle weight measured in sand is constant and cannot be altered much by any grouser design modification.

Verifying or debunking basic design concepts, as was true in soil-vehicle relationship discussions, is only a part of the initial phase of the design process, an aeronautical scientist inferred in describing gas-heated propeller researches. Chief problem is designing gas-heated propellers, he explained, is to get enough heat to the leading edge area without wasting any.

Method for learning about flow of hot gases here was to test 10-ft 2-in. diameter production propellers with hollow blades, both partitioned and unpartitioned. Heated air was ducted through to the blades and thermocouple readings taken. Blade

General Motors Entertains At Annual Meeting Dinner

Part of the General Motors Chorus of 130 men and women whose songs prior to the speaking program delighted and stirred the 3600 members and guests who listened. (Inset: Chorus Director Eduard Ossko)

icing photographs were compared with surface temperature data and heat input values. Out of this work came a factual demonstration of the relative merits of the alternative designs tested.

Finding refinements in behavior patterns carried over to reports on a switch from steel to forged aluminum mountings for the R-4360 Pratt & Whitney aircraft engine. Engineers on this job said the pitfall they had to guard against in the steel-to-aluminum changeover was fatigue failure. They found ways to long fatigue life, while keeping weight low, through flight and torque stand tests.

Aim at Service Needs

Particular emphasis was given to determining the service needs these engine mountings must satisfy.

Car body engineers said that legal regulations impose limitations on design equally as restrictive as those of natural physical phenomena. Body stylists striving for the low-slung look find themselves limited by an Interstate Commerce Commission ruling that the minimum ground-to-centerline distance of headlamp be 30 in. Tail lights must be no lower than 24 in. and no higher than 42 in. from the ground. Car makers also want bumpers set at 18.25 in. from the ground, as specified in the SAE Bumper Heights Standard.

Physiological man, as both driver and passenger, must be catered to if the body engineer is to provide comfort in his design. One designer saw the human body setting the design rules for the car body. A body design that minimizes exposure of the passenger and driver to uncomfortable conditions was labelled as the goal to shoot at.

Designers of vehicle and aircraft equipment agreed that after learning about what can be expected to happen to the part or assembly in service, next step is to decide what to do about it so that the design operates successfully under anticipated conditions.

Because helicopter transmission designers have found high differential thermal expansion in tropical operations, they know what to do about steel bearing races loosening in light metal housings. This happens because aluminum and magnesium alloys have about two and one-half times the linear expansion of steel. Steel liners in aluminum housings help prevent creep.

Facts of life about soil reaction were shown to be yielding better guides to tracked vehicle designers. For example, one such fact is that grouser effectiveness in frictional soils depends on a ratio of grouser height to track width. Thus if a 10-in. track and a 20-in. track are to be used under the same conditions, and if the 10-in. track has 2-in. high grousers, those on the 20-in. track should be at least 4 in. high to get the same grouser effect.

Doubt Commercial Utility

Whether the new vehicle-soil concepts would be equally as effective in design of commercial machines (farm and earthmoving equipment) met with some difference of opinion. Several tractor men held that their equipment does not have to operate in extreme soil conditions, that design for this might sacrifice performance under normal conditions. They pointed to a Corps of Engineers film shown at the meeting, on trafficability over adverse soil conditions, as atypical of terrain worked by their machines.

Designers also learned how lab and flight investigations revealed the most economical design for a gas-heated propeller. Attaching internal metal fins to the leading blade edge together with an additional partition improved internal heat transfer and conducted heat to the leading edge region—where it is needed most.

Flight and lab tests also led to appreciable weight savings in engine mountings, designers of this equipment reported. Aluminum replacing steel for these components cut weight from 134 to 71.5 lb—a

250-lb saving for a four-engine airplane, equal to the weight of one crew member with baggage or some 800 rounds of 50-caliber ammunition. It also extends a sizable dollar saving to airlines, which claim each pound of unnecessary weight costs them $1 per year.

Experimental work also disclosed to these engine mounting designers that sulfuric acid anodizing of these parts offered little resistance to fretting corrosion (also known as friction oxidation), shortening fatigue life. Chromic acid anodizing, said these engineers saved the day by imparting resistance to fretting corrosion to these aluminum alloy parts subjected to high cyclic stresses.

The what-we-do-about-it phase of body design discussions emphasized physical comfort features. Said body engineers, seats are designed to include proper back and leg support, shock-absorbing qualities, and vibration dampening, and prevent eye level loss, muscular fatigue, and body posture that induces poor blood circulation, poor breathing, and abdominal cramping.

Fatigue and irritation from noise are guarded against in body design by proper insulation. Materials such as cardboard, jute, asphalt paper, wool, and rubber are used on dash pads or fire walls to prevent engine noise from coming through. Asphalt and sand compounds are sprayed on floor pans and door panels to deaden sound. Spun glass and fluffed cotton are among the materials cemented to roof panels and hoods to absorb unpleasant noises. Such acoustical treatment, body engineers agreed, adds up to better driving efficiency.

AIR TRANSPORT

Cold Weather Devices Open New Vistas

Based on discussions and two papers presented at one Air Transport session. . . . "Some Tricks in Cold Weather Operation," by **J. T. Dyment**, Trans-Canada Air Lines. . . . "Operational Results of Thermal Anti-Icing," by **M. G. Beard** and **D. North**, American Airlines, Inc. . . . **Both papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

DESIGNERS and operators of air transport aircraft are adding thermal anti-icing to their growing collection of cold-weather-operations tricks, they reported.

One new transport, the DC-6 provides hot-gas wing and windshield anti-icing and electrical-resistance propeller anti-icing. Another, the Convair 240, uses hot gas for wing anti-icing but electrical resistance for windshield as well as propeller anti-icing.

Operators of older transports disclosed that meanwhile it is possible to get satisfactory results from fluid and pneumatic deicing.

Convair and DC-6 Compared

While both the DC-6 and the Convair 240 use heated-air anti-icing for wings, the heat sources differ, it was explained. The Douglas airplane has one combustion heater in each wing. Heater exhaust is carried along the wing in a spanwise duct forward of the front spar and fed between double skins in the leading edge area. Designers of this system were pleased to hear that although these leading edge passages are only 5/32 in. wide, airplanes in service as long as two years have experienced no clogging.

Source of heat for the Convair's wing anti-icing is an exhaust gas heat exchanger. Economical as this is in principle, operators revealed that with early designs of heat exchangers, wing anti-icing cost $4 per hr of flight—or $80 per hr of flight in icing conditions. Main factor in the expense was replacement of heat exchanger tubes that developed cracks after as little as 50 hr of airplane use.

Exchanger Failures Explained

As one discusser explained it, the combination of a corrugated surface against a flat surface subjected certain areas to high stresses, probably beyond their yield strengths at elevated temperatures, then cooling subjected other areas to high stresses. Since the anti-icing system incorporates a temperature-cycling control, it didn't take many applications of wing heat to start a crack in one part of the exchanger or another. Substitution of temperature modulation for "on"-and-"off" cycling might relieve the situation, he suggested.

Design of these heat exchangers is progressing rapidly, however, it was demonstrated by a correction noted at the meeting. When the speaker wrote his paper, the "latest" designs of tubes were running about 400 hr. When he presented the paper, the figure had doubled.

Operators reported that the DC-6's windshield deicing and birdproofing are effective and reason-

ably inexpensive to maintain. Air heated by the cabin heater is ducted between two panes, the inner being the birdproof glass-plastic-glass sandwich. Actually the birdproofing depends on the heating, discussion disclosed. The impact strength of the sandwich is due largely to the vinyl plastic layer, which becomes brittle at low temperatures.

The Convair was described as using a sandwich pane also. In the case of this Nesa glass, the middle layer is a film of metal fine enough to see through. Anti-icing is accomplished by passing a 325-v a-c current through the metal to produce heat. So far, maintenance costs have been high. But operators are so pleased with the protection offered that they are willing to stick with electrically heated glass while the "bugs" are corrected, they indicated.

Why Convair Boots Wear Faster

One operator noted that although the DC-6 and Convair 240 use the same anti-icing boots and timing cycle, Convairs wear out their boots much faster. This he attributed to differences in use: The DC-6 averages 120 min between stops and makes them on large well maintained runways, which the propellers clear by 26 in. The Convair stops every 50 min, often at small airports with less suitable surfaces, and its propellers clear the runway by only 11 in. Abrasion is bound to be more severe with the Convair, he reasoned.

While operators and designers agreed generally that application of heat is the best way to lick icing, one experienced cold-weather operator gave assurance that satisfactory results can be obtained with fluid propeller anti-icing and pneumatic wing deicing. He claimed, and a discusser confirmed, that the secret of adequate fluid propeller anti-icing fluid distribution over both cambered and flat blade surfaces lies in locating the leading edge groove properly. On the speaker's DC-3's, this groove is located about ⅛ in. from the leading edge toward the cambered surface. Otherwise all or most of the fluid will flow over the flat surface. Alcohols used for anti-icing must be anhydrous to prevent corrosion, he said, adding that glycerin isn't worth while because it fouls spark plugs.

Other bits of cold-weather know-how that operators shared with designers present at the meeting included:

1. Use a wind-chill factor, like that of Siple and Pascal of the U. S. Antarctic Service, which considers quantity of heat which the atmosphere is capable of absorbing within a unit time from an exposed surface of unit area. Or, if static conditions are assumed, design for -80 F in order that equipment will function properly at a windy -40 F, which Canadian and some U. S. lines encounter fairly often.

2. Design equipment so that it can be serviced by personnel wearing mitts or gloves. That requires avoidance of intricate locking devices and threaded fastenings that can be overtorqued by men lacking feel through thick gloves or because of numbness.

3. Seal out as much moisture as possible and provide for drainage of any that does gather. Listeners were warned that blowing snow can enter through clearances too fine to admit water. Any moisture that gets in this way or through condensation can cause trouble by freezing in lines or on control surface fixtures.

4. Make oil and vent lines about twice their present diameters.

Fuels & Lubes Sessions Emphasize Combustion RESEARCH

COMBUSTION of fuel in the gasoline engine is slowly giving up its secrets to a group of determined research engineers. New techniques and even a new machine is helping them find out exactly what happens from the time the fuel leaves the carburetor until it is exhausted from the cylinder.

Researches revealed at the meeting showed changes that take place between the time the air/fuel mixture leaves the carburetor and the time it enters the cylinder from the manifold; changes during the period when the mixture is being compressed, but before ignition; and changes in the short interval after compression, when the burning of the fuel takes place. Discussed also were a new

Based on discussions and six papers presented at two Fuels and Lubricants sessions. . . . "Some Fundamental Aspects of the Measurement of Detonation," by **D. R. deBoisblanc**, Phillips Petroleum Co. . . . "The Ignition of Fuels by Rapid Compression," by **C. F. Taylor, E. S. Taylor, J. C. Livengood, W. A. Russell** and **W. A. Leary**, Massachusetts Institute of Technology. . . . "Precombustion Reaction in the Spark Ignition Engine," by **Edmond R. Retailliau, Harold A. Ricards, Jr.**, and **Minor C. K. Jones**, Standard Oil Development Co. . . . "A Study of Mixture Distribution in a Modern Multicylinder Engine," by **R. W. Donahue** and **R. H. Kent, Jr.**, Sun Oil Co. . . . "150 Miles Per Gallon Is Possible," by **R. J. Greenshields**, Shell Oil Co. . . . "The Performance of High Viscosity Index Motor Oils," by **C. L. Fleming, Jr., B. W. Geddes, N. V. Hakala** and **C. W. Weisel**, Standard Oil Development Co. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

48 Exhibitors Show Vehicle, Plane

Aeroquip Corp.
Aluminum Co. of America
Aluminum Industries, Inc.
American Bosch Corp.
American Seating Co.
Auto Specialties Mfg. Co.
Bendix Aviation Corp.
Brush Development Co.
The Buda Co.
Campbell-Wyant & Cannon Foundry Co.
Cleveland Graphite Bronze Co.
Consolidated Engineering Corp.
Continental Motors Corp.
Cummins Engine Co.
DeLuxe Products Corp.
Detroit Gasket & Mfg. Co.
Fram Corp.
The Garlock Packing Co.
Gemmer Mfg. Co.
General Plate Division, Metals & Controls Corp.
Haskelite Mfg. Corp.
Heli-Coil Corp., Inc.
Hercules Motors Corp.
Koppers Co., Inc.

method of measuring detonation, the performance of high viscosity index oil, and some tests made by a small group of engineers who are carrying on "research" in their own backyards to get maximum possible mileage out of the family car.

Mixture Distribution

Constant-speed tests on a typical modern 6-cyl stock engine disclosed at the meeting indicated that comparatively minute details of the induction system, such as the position of the choke valve and its mounting, and any other obstructions in the air passage, have a marked effect on the air/fuel ratio of the mixture actually received by each cylinder. More obvious factors, on the other hand, such as fuel volatility, engine speed, and heat supplied to the inlet air or to the mixture itself, have only a comparatively minor effect.

Thus, contrary to popular belief, it is not possible to control distribution by changes in fuel volatility—or,expressed another way, the light components of a fuel will be unevenly distributed, just as the heavier ones.

Detonation

Ingenious experimental techniques to test knocking were shown to portend much new knowledge as they are more extensively applied—in addition to specifics actually detailed at this meeting.

One of these techniques involves motoring an air/fuel mixture through an unfired engine, which is driven as a compressor by an electric motor. This permits the collection and analysis of large

Equipment at Engineering Display

Link Engineering Co.
Lord Mfg. Co.
The MB Mfg. Co.
McQuay-Norris Mfg. Co.
Mechanics Universal Joint Division, Borg-Warner Corp.
Monroe Auto Equipment Co.
Petroleum Advisers, Inc.
Physicists Research Co.
Pierce Governor Co.
Ramsey Corp.
Scully Signal Co.
Sparks-Withington Co.
Spencer Thermostat Division, Metals & Controls Corp.
Spicer Mfg. Division, of the Dana Corp.
Stewart-Warner Corp.
Titeflex, Inc.
Tinnerman Products, Inc.
Torrington Mfg. Co.
Truck Equipment Corp.
Vickers, Inc.
Victor Mfg. & Gasket Co.
Waldes-Kohinoor, Inc.
Waukesha Motor Co.
Zollner Machine Works

quantities of fuel that has been subjected to compression-stroke conditions, but that has not been ignited and burned.

Analysis of the mixture coming from the engine showed that changes or "prereactions" do take place in the mixture as it is being compressed before ignition takes place.

These prereactions, it appears, play an important part in the knocking phenomenon, for when they do occur, the fuel eventually ignited by the spark is no longer the original hydrocarbon material but a mixture of many hydrocarbons and oxygenated compounds. For instance, in a typical test of a blend of 75% iso-octane and 25% *n*-heptane, only about 50% of the feed survived the prereactions.

Further study of these prereactions showed them to be a function of both fuel type and engine operating variables. Engine design is also considered to have a significant influence, but this problem has not yet been studied.

Two engine operating variables having a major influence are intake temperature and compression ratio.

Thus it follows from these tests that the proper selection of fuel and the control of engine design and operation should lead to optimum performance with respect to detonation, as well as power and economy.

Another technique described for studying fuel ignition involves a rapid-compression machine, designed to give a compression rate so high that it slows down the reaction process sufficiently to allow study of what goes on in the mixture before explosion occurs.

Work with this machine, it was said, can be related to the detonation tendencies in spark-ignition engines—where compression is increased *continuously* until the mixture is ignited and while combustion is taking place—because the factors that result in a long delay and a slow rate of pressure rise in the last stages of the reaction in the compression machine are also the factors that contribute toward freedom from detonation in an engine.

With the aid of the rapid-compression machine, photographic records have been made of piston motion and the variations in pressure that occurred within the cylinder during autoignition. The explosion curve could vary anywhere between two extreme types, tests show. In one extreme, the combustion takes place suddenly at the end of the delay period and appears as a discontinuity on the trace. This type of explosion was always found to be followed by high-frequency oscillations.

In the other extreme, the pressure rise is very gradual, starting shortly after the end of compression and progressing slowly to the maximum value.

Simultaneously with the records of pressure and piston motion, photographs taken at about 10,000 frames per sec to obtain a record of flame propagation reveal, according to their takers, that reactions are usually progressive starting from one or many points; also, a correlation exists between the rate of inflammation and the rate of pressure rise in the corresponding pressure-time record.

In addition, most of the flame photographs show that the reaction is not very homogeneous, and that great numbers of small luminous spots are formed, which persist for long intervals with surprising stability of size and shape. The nature of this phenomenon is not understood. It has been established, however, that these spots are not due to the presence of droplets of fuel but may be due to particles of carbon.

A third major attack on detonation, outlined at the meeting, presented a method of measuring the pressure disturbances involved in detonation directly, without the results being affected by the response of the cylinder wall.

Instrumentation for determining knocking characteristics of motor fuels according to both the ASTM motor and the Research method was described.

The signal is picked up by a system that includes a band-pass filter that cuts off frequencies, for example, over 5000 cps. When the cutoff is made at this frequency, no essential information is lost. In fact, this value is typical for detonation in unsupercharged engines, but, at the same time, it is below the lowest normal mode of oscillation in the CFR engine, so it is possible to reject this frequency to the point that it does not interfere with the measurements.

V. I. Improvers

Other tests reported indicate that when certain additives are added to oils to improve their viscosity index—a measure of the change in viscosity of an oil with temperature—the improvement in low-temperature starting and oil consumption anticipated is actually obtained under service conditions.

A comparison of oils containing improvers with straight mineral oils shows that:

1. High V.I. motor oils offer the readiest means of combining good low-temperature starting characteristics with low oil consumption properties in a single crankcase lubricant.
2. The low-temperature starting properties of high V.I. oils containing certain improvers are identical with those of straight mineral oils having the same viscosity at the low temperature under consideration.
3. The oil consumption properties of high V.I. oils containing improvers are identical with those of straight mineral oils having the same viscosity at 300 F.

150 Mpg

What some research engineers and chemists do in their spare time was indicated by data disclosed on attempts to modify the family car so as to get the best possible mileage out of it. With each engineer working out his own ideas on his own car, one of the group in 1949 attained the amazing mileage of 150 mpg with a 1947 Studebaker. No one car model or design appeared to have any particular advantage over another in this informal contest. It was the modifications that were built in this car, especially those designed to reduce rolling resistance to an absolute minimum, and the driving technique used that are responsible. As a matter of fact, it seems the runner up was a 1924 4-cyl Chevrolet, which actually got 158 mpg. (It didn't win because of a car weight handicap, due to its much lighter weight.)

The maximum mileage of the Studebaker was 28 mpg in top gear between 10-20 mph—before any modifications were made.

Changes included: increasing the rear-axle ratio and tire size; buffing off the tire tread, leaving a narrow, smooth, thin rubber tread for contact with the road; increasing tire pressure to 110 psi; using SAE 10 motor oil in transmission, differential, and crankcase; increasing the compression ratio from 6.5/1 to 10/1 by planing off the head; removing the fan belt, so that engine accessories weren't operated, and removing the accelerator pump.

Driving Technique Used

Although these changes increased the mileage obtained considerably, most of the 150 mpg was due to a special driving technique. The car was accelerated at full throttle in top gear from 5 mph to about 20 mph. The engine was then stopped and the car allowed to coast until it slowed down to 5 mph, at which time the engine was restarted and the cycle repeated.

One engineer thought we shouldn't crow too much about the wonderful economy of the modern engine, since the runner up was a 1924 model with low compression ratio and lacking many of present-day improvements.

Another discusser said this work points up the existence of a great opportunity for progress, although he stressed that the difference between the 150 mph reached in this contest and actually mileages obtained by cars today represents the engineering compromise necessary to attain such desirable characteristics as good riding comfort, high acceleration, and low maintenance.

Safety and Economy Are No. 1 Needs of

FARM AIRCRAFT

Based on discussions and four papers presented at one Aircraft session. . . . "Accidents in Crop Control Flying," by **B. W. Ashmead**, Bureau of Safety Investigation, Civil Aeronautics Board. . . . "Needed, A New Agricultural Airplane," by **Howard Hasbrook**, Aero International Co. . . . "A Helicopter for Agricultural Work," by **Charles Kirchner, Jr.**, Kaman Aircraft Corp. . . . "Airplane Spray and Dust Application," by **O. K. Hedden** and **D. A. Isler**, U. S. Department of Agriculture. . . . **These papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

TO do their share in meeting the ever-increasing demands for agricultural spraying and dusting, both aircraft and their dispensing equipment must be designed specifically for this type of work, discussion at the meeting indicated.

The day of the modified trainer and the second-hand commercial biplane with spray and dust equipment assembled from available products is clearly over. Their use is uneconomic, it was disclosed, because they have insufficient payload, high maintenance and repair costs, poor dust and spray coverage, and—what is much worse—they are highly unsafe.

Many pilots have been killed or seriously injured while using these planes for dusting and spraying. The number of such accidents is increasing at an alarming rate, according to a CAA Bureau of Safety Investigation statistician, who pointed out that in 1943 there were only 27 crop-control accidents, whereas in 1948 there were 224, of which 61 involved fatalities or serious injuries to personnel. Pilot error of one sort or another was far and away the most frequent primary cause of these accidents.

It was agreed, however, that the pilots who fly these planes are, for the most part, a careful, skilled, and experienced group—80% of the accidents occurred to pilots whose experience ranged from 1000 hr to over 3000 hr of flying.

The fact of the matter is, it was agreed, that crop-control flying is an extremely hazardous occupation and the pilot must be given every possible aid. All felt that the best answer is to give him a safer plane.

Two approaches to the problem of providing suitable aircraft were discussed; one involves the use of the conventional airplane, the other, the helicopter.

Conventional Airplane Design

Since stalls and collisions are definitely the most common types of accidents, according to the CAA reports, two developments placed high on the list of requirements for an airplane designed specifically for agricultural work were: the stall-resistant airplane and better visibility for the pilot.

Until the stall-resistant airplane is available, it was suggested that installation of stall-warning indicators might be desirable, for CAA reports show that only a small percentage of the stall accidents have occurred on planes having these gadgets.

Better visibility would accrue from a flat engine as well as from having the pilot placed high (but well protected) in a deep fuselage and slightly forward of the wing center-of-lift position, discussion brought out. One member of the audience thought that the high-wing plane would give better visibility, but others recommended the low-wing type because, as the inner wing goes down on turns, which are frequent, the pilot is still able to see the ground from them; whereas the inner wing of the high-wing plane actually obscures the ground at this time.

Helicopter Design

During 1948 helicopters were involved in 15 accidents, according to statistics, only four of which resulted in death or serious human injury—and all four of these were caused by persons walking into the tail rotor.

Such accidents could not occur with the K-225 helicopter described at the meeting, for this machine has no tail rotor, torque compensation being accomplished by means of intermeshing twin rotors, which clear the ground by 6 ft 4 in.

This helicopter, designed specifically for agricultural work, has actually been used successfully in combating crop-destroying insects and diseases, where its maneuverability, low flight speed, ability to land in and take off from small clearings, and ability to operate under conditions of limited visibility are of inestimable value.

Dispensing Equipment

The dusting and spraying equipment now being used in aircraft needs a lot of improving, according to those studying this application. Some of the specific problems mentioned were:

1. The design of an aircraft hopper that feeds dust to the dispensing apparatus at a uniform rate.
2. Means for distributing the spray or dust uniformly across the swath.
3. Tanks or hoppers must be located conveniently and have openings of ample size to allow rapid loading.
4. Spray equipment must be designed to give droplets of more uniform size, for if the drops are too small they tend to drift excessively and insects will generally eat around the splash from globules that are too large.
5. Present-day equipment does not give the spray rates wanted, which are comparable to the 200 gpm used in refueling transport aircraft.
6. Finally, whatever equipment is used must be kept light in weight, so as not to penalize payload, and have high strength to ensure safety.

About

JOHN G. WOOD, a veteran of 43 years in the automobile industry, has retired from his position of executive assistant for engineering of the Chevrolet Motor Division, General Motors Corp., Detroit. He is a former chief engineer of Chevrolet. He began his professional life as a draftsman for the National Motor Vehicle Co., Indianapolis, Ind., after graduation from Purdue and Stanford Universities. Wood was associated with other General Motors divisions, including Oldsmobile, for six years before joining Chevrolet in 1933. He is an SAE past vice-president representing Passenger Car Engineering, and served for several years on the SAE Public Relations and Publication Committees.

R. B. HAYNES has recently been appointed to the newly-created position of vice-president in charge of manufacturing of the various divisions of Dana Corp., Toledo, it was announced by **R. E. CARPENTER**, president. He joined the Spicer Mfg. Corp., now a division of Dana Corp., in 1935, and was formerly works manager of the Toledo plant.

ALVAN J. HERZIG has recently been elected president of the Climax Molybdenum Co. of Michigan, Detroit, a research subsidiary of the Climax Molybdenum Co. He joined the company as chief metallurgist in 1931 after serving as research associate at the University of Michigan, Ann Arbor.

CHARLES R. NOLL has been appointed director of automotive products engineering in the newly-formed Product Development and Product Engineering section of Gulf Oil Corp., Pittsburgh, Pa. He joined Gulf in 1924 and has recently been serving as manager of lubricating sales, Automotive Division. Noll's new duties will deal with the application of the firm's fuel and lubricant products to automotive and motorized equipment.

COLE

ARNOLD

EDWARD N. COLE, chief engineer of the Cadillac Motor Car Division of General Motors Corp. since 1946, has recently been appointed works manager of the division. He joined Cadillac in 1930. Cole is SAE Passenger Car vice-president. Succeeding him as chief engineer is **CHARLES F. ARNOLD**, who formerly held the position of assistant chief engineer since 1946. He joined Cadillac in 1925.

JOSEPH GESCHELIN, Detroit editor, Chilton Publications, has presented several papers summarizing the design and operational features of all automatic transmissions now in regular production. The first of these talks was before the SAE Southern New England Section in Hartford at its December meeting. The second, at the SAE Milwaukee Section on Feb. 3, brought the summary up-to-date with the inclusion of the Studebaker and Chevrolet transmissions. The Milwaukee paper also covered some pertinent comments as to the field for torque converters in the truck and tractor industry. The summarization was so designed as to provide a quick picture of the major design elements of each type of drive, together with comparisons of operational features of interest to a car owner.

LELAND E. WELLS has been appointed Exide's chief engineer, it was announced by **L. E. LIGHTON**, vice-president of the Electric Storage Battery Co., Philadelphia. He brings to his new position 30 years' experience in the battery business with the Willard Storage Battery Co. of Cleveland, where for the past 12 years he was chief engineer. Wells is serving on the SAE Electrical Equipment Committee and subcommittee on Storage Batteries.

DR. ALEXANDER KLEMIN, former director of the Guggenheim School of Aeronautics at New York University, has joined "Aero Digest," New York City, as Technical Editor. In 1925 he became associated with NYU, designing and supervising the construction of their aeronautical engineering laboratories, and remained as director until 1942. Since then, he has been serving the aviation industry and the U. S. government as a consulting engineer.

W. R. WYKOFF has joined the Los Alamos Scientific Laboratory of the University of California as chemical engineer, working on design and construction of equipment for the processing of radioactive materials. He was previously associated with the Battelle Memorial Institute as research engineer.

Members

RALPH R. MATTHEWS recently retired as executive vice-president of the Battenfeld Grease & Oil Corp. He joined Battenfeld in 1928 as vice-president in charge of sales. Starting his career in the petroleum industry as a chemist, he later became the third member of the Petroleum Division of the U. S. Bureau of Mines. He left the Bureau to join Shell Oil Co., Martinez, Calif. He was transferred to be chief chemist of Roxana Petroleum Corp. (later Shell Oil Co.) and then moved to the Wood River, Ill., refinery when it was completed. Matthews assisted in the organization of SAE Kansas City Section and served as its chairman in 1932-1933 and 1940-1941.

HENRY LOWE BROWNBACK is now American technical and commercial adviser to la Regie Nationale des Usines Renault at Billancourt, France, Europe's largest motor car factories.

SIDNEY E. MILLER has been appointed vice-president in charge of engineering of the American Bosch Corp., Springfield, Mass. He was formerly manager of the corporation's Engineering Division.

CARL C. SPANGENBERGER has been appointed chief engineer of the Union Asbestos and Rubber Co., Cicero, Ill. He had been associated with Lycoming Division of the Avco Mfg. Corp., in the capacity of superintendent of experimental engineering.

GEORGE W. ELY is now an engineer working on new developments in fuel control for jet engines with Stromberg Carburetor Department, Bendix Products Division, Bendix Aviation Corp., South Bend, Ind.

RICHARD S. WOODBURY has recently joined the Lanova Corp. of Long Island City, N. Y., as executive assistant to the president. He was previously assistant to the vice-president of American Bosch Corp., Springfield, Mass.

QUENTIN BENEDICT has become supervisor of distillation and treating with the Deep Rock Oil Corp. of Cushing, Okla. Formerly he was a chemical engineer with the Ashland Oil and Refining Co., Ashland, Ky.

RALPH R. TEETOR, president, Perfect Circle Piston Ring Co., was host to three distinguished educators during their visit to Hagerstown, Ind., just before the New Year. The guests were Harold Stassen, president of the University of Pennsylvania (Teetor's alma mater); Dr. Thomas E. Jones, president of Earlham College (of which Teetor is a trustee); and Dr. Frank Sparks of Wabash College.

JAMES C. McROBERTS is an engineer with the Jet Engine Controls Group at Bendix Products Division of Bendix Aviation Corp., South Bend, Ind. He was formerly connected with Lycoming Division of the Avco Mfg. Corp., Williamsport, Pa., where he was 1949-1950 vice-chairman of SAE Williamsport Group.

JAMES H. KINDELBERGER, chairman of the board and chief executive officer of North American Aviation, Inc., has been elected 1950 president of the Institute of the Aeronautical Sciences. He succeeds **WILLIAM A. M. BURDEN**, aviation consultant, Smith, Barney, and Co., New York City, 1949 president of the Institute.

Other new IAS officers include SAE members **W. E. BEALL**, vice-president, engineering and sales, Boeing Airplane Co., and **WILLIAM LITTLEWOOD**, vice-president of engineering, American Airlines, Inc., who have been elected vice-presidents. **EMERY A. SPERRY, JR.**, vice-president and treasurer, Sperry Products, Inc., has been elected treasurer.

DAVID C. PETERSON has been named director of engineering and manufacturing of Division One of Stewart-Warner Corp., Chicago. He had been director of engineering of the corporation since 1946.

HARVEY W. HANNERS, formerly assistant chief engineer, has recently been appointed chief engineer of the Superior Engine Division of the National Supply Co., Springfield, Ohio. He joined the company in 1941 as a development and research engineer. Hanners served as vice-chairman of the Springfield District SAE Dayton Section from 1945 to 1947.

RAY J. MILLER has been named manager of the Research Engineering Department of Dearborn Motors Corp., Detroit. Prior to joining Dearborn Motors in May, 1949, he had served as chief engineer and assistant director of research for the Bendix Aviation Corp. research laboratories in Detroit for six years.

JOHN D. SMETZER, formerly industrial relations director, has been appointed vice-president in charge of industrial relations of the Weatherhead Co., Cleveland. He joined the company in 1927.

HENRY JENNINGS has been named technical editor of "Fleet Owner," the truck publication recently acquired by McGraw-Hill Co., it has been announced by **LEON F. BANIGAN**, editor. Jennings has been a member of the SAE Technical Division staff since 1942, and has been secretary of its technical committees in the transportation and maintenance, truck and bus, engine, and electrical equipment fields. He has a wide background of both editorial and industry activity, including a number of years with "Commercial Car Journal," following service engineering work with such companies as Yellow Truck & Coach Mfg. Co., and Larrabee Dayo Motor Truck Co.

CLYDE L. SAVAGE, formerly chief engineer of Haberstump and Harris, Inc., Detroit, has recently established his own engineering organization under the name of Savage Engineering Co., same city. In his new activities he is specializing in product design and in engineering problems associated with production.

PERRY W. PRATT has been appointed assistant chief engineer of the Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn. He joined Pratt & Whitney as a test engineer in 1937, and before his appointment was project engineer.

SIDNEY G. HARRIS has joined the Magnus Chemical Co., Inc., Garwood, N. J., as a sales engineer. He was formerly manager of the Automotive and Chemicals Division of E. F. Drew & Co., New York City. Harris was chairman of SAE Metropolitan Section during 1934-1935.

W. I. FORD, chief field engineer of the U. S. Rubber Co., Detroit, recently returned from a two week trip to Sweden and England. On this trip he visited Gislaved, where U. S. Rubber has an associated plant, and other industrial centers. He stopped at London for tire and other automotive engineering discussions.

STUART P. HALL has been appointed editor of "Design News," Detroit. After graduating from Rensselaer Polytechnic Institute, Troy, N. Y. in 1940, he joined Buick Motor Division, GMC, Flint, and later resigned to become associate editor of "Product Engineering," New York City. He became managing editor of "Design News" last year. This year Hall is serving as editor of the SAE Detroit Section "Supercharger."

FLOYD L. MENG has recently joined the United Conveyor Corp., Chicago, as a field engineer.

NATHAN WINARSKY is now a sales manager for the Diamond T Motor Car Co., at Newark, N. J.

LEO A. SNYDER has been appointed vice-president and director of Saunders Petroleum Co., Kansas City, Mo., where he will be engaged in buying and selling petroleum products. He had been associated for 28 years with the Champlin Refining Co., Enid, Okla., where he was vice-president.

FRED L. HALL has recently organized his own company in Florida which will act as manufacturers' agents and will distribute and service a general line of boats, engines, motors, and lawn mower and maintenance equipment. He was formerly vice-president, director of sales, service, and advertising for the Kiekhaefer Corp., Cedarburg, Wis.

ALBERT J. AUKERS, chief engineer of the Victor Mfg. and Gasket Co., Chicago, was recently elected a member of the board of directors. He has been with the company since 1932 and has held various positions in research, production, sales and product engineering.

CHARLES H. GLASIER, JR., has been appointed manager of distribution for Air Reduction Sales Co., a division of Air Reduction Co., Inc. He joined Air Reduction in 1936 and after eight years in the distribution department, was appointed supervisor of motor truck equipment. In 1947, he was named assistant distribution manager.

JOHN McVEIGH has become special development engineer with Kennametal, Inc., Latrobe, Pa. Prior to joining Kennametal, he was project engineer in charge of all gas turbine developments with Continental Motors Corp., Detroit.

PROF. C. STARK DRAPER, of the M.I.T. aeronautical engineering department, and an associate, Dr. Y.-T. Li, have developed an improved high-performance engine indicator. Although the new instrument applies commonly-used strain gage principles for measuring pressures inside an engine, it largely overcomes defects of previous devices by the use of a curved, instead of flat, pressure-recording drum and by refinements in the application and instrumentation of the strain gage itself.

ABNER DOBLE, consulting mechanical engineer, has moved from Wauwatosa, Wis., to San Francisco, Calif.

KENNETH H. JACOBS, research engineer in the applied mechanics department of Armour Research Foundation of Illinois Institute of Technology, Chicago, has been named supervisor of that department's propulsion section. He will supervise the Foundation's basic and applied research work on jet propulsion, rockets, and propellants and fuels. Jacobs has been associated with the Foundation as an engineer since 1946.

ROBERT J. WOODS, chief design engineer of Bell Aircraft Corp., Buffalo, N. Y., has recently been awarded the medal of freedom by President Truman for meritorious civilian services during World War II. The citation recognizes Wood's services in Europe as a technical representative for the United States Air Force in 1945.

HENRY C. GREBE, formerly body engineer of Ford Motor Co., Dearborn, has been appointed chief body engineer of that company by **HAROLD T. YOUNGREN**, vice-president-engineering. Grebe previously had been senior engineer in charge of the body engineering of Fisher Body Division, General Motors Corp., Detroit. During World War II he was supervisor of drafting and engineering for all Army tank production.

COL. JESSE G. VINCENT, who has headed Packard engineering for the past 37 years, has been named executive vice-president of the company, succeeding Hugh J. Ferry, who has been named president. (Retirement of **GEORGE T. CHRISOPHER** as president of Packard was announced in the November, 1949, SAE Journal on p. 77.) Col. Vincent was SAE President in 1920, 10 years after his election to membership in the Society.

GURNAM S. GUJRAL is a metallurgist with the John Deere Tractor Co., Waterloo, Iowa. He recently received his M.S. degree from the University of Illinois.

ALBRECHT GOERTZ recently became a designer with Carl Otto, New York City, industrial designers. He was formerly connected with Raymond Loewy Associates.

M. GORE KEMP, former Southwest regional sales manager for Koppers American Hammered Piston Rings, Piston Ring Division of Koppers Co., Inc., has been appointed manager of automotive replacement sales.

S. D. HERON, consulting engineer, is co-author of "Development of Aircraft Engines and Fuels," published by the Harvard Business School, Division of Research. Robert Schlaifer, assistant professor of business administration at Harvard, is the other author. Heron's section of the book deals with the development of aviation fuels, from the first World War to the end of the second. He traces joint government-industry cooperation that led up quantity production of 100-octane gasoline, and discusses fuel supply problems during World War II. The history of aircraft engine development, with emphasis on research and development, is authored by Schlaifer. He discusses development of specific engines, including radial, liquid-cooled, and jet types. Price of this 754-page book is $5.75.

BADGLEY

DAWSON

O. V. BADGLEY, vice-president of General Motors Corp., and general manager of its Delco-Remy Division at Anderson, Ind., has recently retired after 41 years service. Succeeding him is H. D. DAWSON, who has been serving as assistant general manager of the division since 1947. Dawson joined Delco-Remy in 1925.

H. G. BATCHELLER, has been elected chairman of the board of Allegheny Ludlum Steel Corp., Pittsburgh, Pa. He had been president of the corporation since 1938.

PHILIP M. KLAUBER, formerly in the Engineering Department of the Solar Aircraft Co., San Diego, has been appointed assistant to the president of that company.

RAYMOND R. BEARDSLEY has resigned as secretary of the Sealed Power Corp., Muskegon, Mich. In order to carry out his desire to devote more of his time to other interests, he is retiring from active management of the company. He will continue as vice-president and a director of the company. Beardsley joined Sealed Power 30 years ago.

JOHN L. WILSON is owner of the John L. Wilson Mfg. Co., Madison, Conn. He was formerly supervisor of engine field liaison, Chance Vought Aircraft Division, United Aircraft Corp., Dallas, Tex.

STEPHEN JACK is now senior test engineer working on experimental and development engineering and testing of ramjets with Wright Aeronautical Corp., Wood-Ridge, N. J. He had been test engineer with Wright.

CLIFFORD F. HOOD, formerly president of the American Steel and Wire Co., Cleveland, a United States Steel subsidiary, has been elected president of Carnegie-Illinois Steel Corp., Pittsburgh, the principal steel producing subsidiary of U. S. Steel.

E. F. RIESING, manager of automotive engineering and sales, Firestone Industrial Products Co., Detroit, presented a paper covering detailed design data on natural and synthetic rubber at the seventieth ASME Annual Meeting last November. Among the items discussed by Riesing in his paper are general properties of basic elastomers; applications and processing characteristics; detailed design nomographs based on "shape factor" and compression modulus; explanation of the effect of temperature on compression modulus; and shear design data.

W. E. BURNHAM is now chief of the Mechanical Design Unit at Boeing Airplane Co.'s Wichita Division. He was formerly a staff engineer with the Beech Aircraft Corp., Wichita, Kans. Burnham is also carrying on a small consulting practice covering, for the most part, propeller design problems.

WALTER H. BEECH, president and board chairman of Beech Aircraft Corp., Wichita, Kans., succeeds **C. J. REESE**, president of Continental Motors Corp., Detroit, as chairman of the Personal Aircraft Council of Aircraft Industries Assn., and as a member of the AIA board of governors.

ROBERT F. LYBECK, manager of aviation sales in the New England Division of Esso Standard Oil Co., Boston, Mass., has recently been elected president of the Aeronautic Association of Boston.

JOHN W. ENELL has recently received the degree of Eng. Sc. D. from New York University and has been appointed assistant professor of administrative engineering there.

CHARLES K. TAYLOR has joined the Morse Chain Co., Detroit, as a sales engineer. He formerly held a similar position with the L. G. S. Spring Clutch Corp., Indianapoils, Ind. Taylor is an active member of the SAE Indiana Section, having been Field Editor and Publicity Chairman for 1946, Reception Committee Chairman during 1947, Placement Chairman for 1948 and Secretary for the section during 1949.

ISRAEL KATZ, now associate professor of mechanical engineering at Cornell's Sibley School, has drawn on his teaching experience and his summer employment at Pratt & Whitney Aircraft to produce "Principles of Aircraft Propulsion Machinery." This latest addition to Pitman's Aeronautical Engineering Series covers powerplants from the 1902 Manly engine to the latest jet and rocket types, with emphasis on piston and turbine engines. Descriptive and analytical material alternate. Each chapter concludes with a list of references—many to SAE publications—planned, the preface says, to stimulate interest in the technical literature.

WALTER N. DEISHER, formerly vice-president and general manager, has reecntly been appointed to the newly-created post of director of manufacturing at A. V. Roe Canada, Ltd.

ERWIN L. GEHRKE is now a sales manager with the Rochester Gear Works, Rochester, Mich. He was formerly general manager of the R. B. M. Division of Essex Wire Corp., Lancaster, O.

O. P. CROMWELL, formerly service representative with the Truck & Coach Division of General Motors Corp., Seattle, Wash., is now a district representative for the corporation at Oakland, Calif.

R. W. LOHMAN, formerly a development engineer with the Vaportron Corp., Boston, Mass., is now an electrical engineer with the Berkeley Scientific Co., Richmond, Calif.

RICHARD G. MARKHAM, formerely an industrial engineer with the Lily-Tulip Cup Corp., New York City, has recently joined the Citrus Reaming & Equipment Corp., Fullerton, Calif., as a purchasing agent.

R. L. KNIGHT is an administrative assistant and purchasing agent with the Phoenix Research Laboratory of Motorola, Inc., Phoenix, Ariz. He was formerly an engineer in the Cook Research Laboratory, Chicago.

HERBERT J. GREENBERG has rerently joined the Piasecki Helicopter Corp., Morton, Pa., as a flight test engineer. He had previously been a flight engineering inspector and engineering test pilot with the Civil Aeronautics Administration, Los Angeles, Calif.

C. LINCOLN CHRISTENSEN has recently joined the Civil Aeronautics Administration, Washington, D. C., as a consultant.

OLIVER W. INSKEEP is project engineer with Dalmo Victer Co., San Carlos, Calif., manufacturers of airborne radar antennas. He was formerly production engineer with Wilkerson-Nutwell, Fresno, Calif.

EDWIN M. FISK is now general manager and vice-president in charge of engineering at the American Fisk Engine Co., Inc., Dallas, Tex. He was formerly chief engineer with the Reed Mfg. Co., Los Angeles, Calif.

DONALD L. WILLIAMS is now a senior design analyst with the Ranger Engine Division of Fairchild Engine & Airplane Co., Farmingdale, L. I., N. Y. He was formerly senior engineer of special projects with Aircraft Division of Packard Motor Car Co., Toledo.

M. A. RHOADS is now a chief engineer in the Hydraulic Division of the Auto Specialties Mfg. Co., St. Joseph, Mich. He was formerly chief engineer with the Columbian Vise & Mfg. Co., Cleveland.

GEORGE E. HARRIS, formerly a manufacturer's representative for the Kay Sales Co., Kansas City, Mo., is now holding a similar position with the W. E. Fry Co., same city.

W. S. DACK, formerly road test engineer with the White Motor Co., Cleveland, is now an engine design engineer with that company.

JAMES F. CONNELL is now a design engineer in the Research and Development Laboratory of the Standard Products Co., Lakewood, Ohio.

THEODORE E. BOKEMEIER, formerly a salesman of Chrysler and Plymouth cars with the Hessel Implement Co., Gresham, Ore., is now director of the Placement Advisory Service, Portland, Ore.

LAURENCE C. HUFFMAN has recently been appointed coach service engineer of the Truck & Coach Division of General Motors Corp., Pontiac, Mich. He was formerly a service representative for the corporation.

J. B. WASSALL recently became chief project engineer with Lockheed Aircraft Corp., Burbank, Calif. He had been chief production development engineer.

R. LYLE BRACE is sales manager and partner in the firm of Controlled Oil Products Co., Indianapolis, where he is engaged in sales promotion and lubrication engineering.

WILLIAM P. MOHAN has joined the Aviation Gas Turbine Division of the Westinghouse Electric Corp., Lester, Pa., as a design engineer. He was formerly supervisor of the Experimental Test Division of Wright Aeronautical Corp., Wood-Ridge, N. J.

JAMES D. MOONEY, chairman of the board of Technical Managers, Inc., New York City, has been appointed vice-chairman of the Greater New York 1950 March of Dimes, directing that fund-raising organization.

PAUL G. HOFFMAN, administrator with the Economic Cooperation Administration, Washington, D. C., was grand marshall of the 1950 Tournament of Roses parade on Jan. 2 at Pasadena, Calif.

LOWELL H. GRISELL is a mechanical engineer with Hercules Motors Corp., Canton, Ohio. He was president and general manager of Kermath Mfg. Co., Detroit.

OBITUARIES

ELBRIDGE F. BACON

Elbridge F. Bacon, assistant chief engineer of AC Spark Plug Division, General Motors Corp., died Dec. 15 after an illness of several weeks. He was 51 years old.

A native of Detroit, Bacon graduated from the University of Michigan in 1922, a bachelor of science in aeronautical engineering. He was one of the automotive industry's foremost authorities on automotive instruments and related devices. During the war he contributed greatly to the production and development of bombsights and gunsights, which AC produced for the United States Air Forces and Royal Air Force of Great Britain. He joined the Society in 1926.

ROBERT CHARLES ENGELMAN

Robert Charles Engelman, assistant chief engineer of Clark Brothers Co., Olean, N. Y., died Nov. 30. He was 50 years old.

Educated in Germany, he joined Western Electric Co., Chicago, soon upon his arrival to this country. He was with Drying Systems, Inc., for several years working on product development, and joined T. R. Dresser Mfg. Co,. Bradford, Penna., as chief engineer.

He transferred to Olean in 1937 with the Clark concern, one of the Dresser Industries. He joined the Society in 1937. He was the 1942 winner of the James F. Lincoln Arc Welding Foundation award for development work he did in that field.

ROY G. NOLL

Roy G. Noll died suddenly at his home in Dearborn on Dec. 15, 1949, after a long illness. He was 66.

A graduate of Carnegie Institute of Technology in 1908, Noll started his automotive career with the Standard Automobile Co. after he had completed his first year of college. In June 1914 he joined Ford Motor Co. in Pittsburgh and a few months later was promoted to chief inspector and finally to assistant superintendent of the branch.

During World I he served with the Ordnance Reserve Corps as a lieutenant. After his discharge in 1918, he returned to Ford where he was assistant manager of the Reading, Pa., branch. In 1933, he went to the Philadelphia branch and later to the Chester branch. In 1940 he was transferred to Dearborn where he served as work standards analyst in the airplane engine division until the end of World War II. He retired from Ford in 1948. Noll joined SAE in 1912.

TECHNICAL COMMITTEE *Progress*

Hydraulics Group Sparks Aero Standards Advances

AT its most recent meeting, SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment, continued to provide industry and Government engineers with the facilities for reconciling differences in AN hydraulic standards. Prominent among the items discussed at this three-day meeting by the 106 hydraulic specialists attending were those on the basic hydraulic system design specification, AN-H-2; impulse testing requirements; cylindrical accumulators; and pneumatic systems.

Committee Chairman B. R. Teree, New York Air Brake Co., reports that important agreements were reached on revisions to AN-H-2, Hydraulic Systems, Design, Installations and Tests of Aircraft (General Specifications for). These new revisions will apply to design of future hydraulic systems and are aimed at simplifying design of these systems for the hydraulic engineer.

Spec Surveyed

The specification was reviewed and discussed in the light of a survey conducted by the Committee under the supervision of F. H. Pollard, Republic Aviation Corp.

Both industry and Government engineers at the meeting also were interested in a report by H. Cornish, Douglas Aircraft Co., Inc., on aircraft hydraulic system pressure surges. According to an industry survey he made, Cornish found airframe and equipment manufacturers were experiencing surges 1.20 to 3.00 times system pressure. Average was about 1.62 times system pressure.

Because components for hydraulic systems are designed, built, and tested to withstand specific system pressures without taking into consideration these surges, which produce higher pressures in the system, industry engineers feel impulse testing requirements must be defined.

They recommended that the services undertake research to establish the significance of impulse peak pressures in hydraulic systems and to evaluate factors such as rate of pressure rise. Such studies they feel, should lead to a specification that will define and standardize impulse testing. A long range proposal made is that a separate test specification eventually should be prepared, because of the specialized and difficult nature of impulse testing, and that detail requirements for impulse testing be removed from unit specifications.

Another item discussed at the meeting was the standardization of cylindrical hydraulic accumulators for the 1500 and 3000 psi pressure classifications.

Cylindrical accumulators are easier to install and to manufacture than the spherical type. But more important, present diaphragms of certain spherical accumulators are giving trouble; and tests show the cylindrical type to hold an advantage in this respect.

Because of industry interest in these cylindrical accumulators, a subcommittee, under R. H. Davies, Parker Appliance Co., has been appointed to draft a proposed standard on them. The subcommittee will concern itself with dimensions. Agreement already has been reached among industry engineers on both diameter and capacity for five sizes—25, 50, 100, 200, and 400 cu in.

From hydraulics, the meeting conferees switched to pneumatic systems, with Air Force engineers showing keen interest in this field and an eagerness to cooperate with industry in testing pneumatic system equipment.

Air Materiel Command men reported in several years of testing, they found these important advantages for pneumatics over hydraulics in aircraft: (1) air is universally available, (2) no fire hazard, (3) ready storage of power and instantaneous power availability, (4) practically instantaneous actuation, (5) operation practically independent of temperature, (6) relatively small transmitting lines, with no return lines needed, (7) cleanliness in system, and (8) small horsepower required for prime mover. Weight studies made by two companies showed weight savings ranging from 33 to 41% for pneumatics over hydraulics for two specific airplanes.

Air System Drawback

Main disadvantage found with pneumatic systems is the low inherent efficiency of a compressed air system.

Chief problem said to be facing the Air Force at present is development of an air compressor capable of producing the pressure needed and operating on available lubricating oil. Two experimental compressors already have been developed—a 1500-psi unit and a 3000-psi unit. They have operated successfully on reciprocating engines and, it was stated, could also be used experimentally on jet aircraft. Aircraft designers were advised to acquaint themselves with these compressors, which will soon be available for installation on experimental and production aircraft.

SAE

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Strive for Standard Helicopter Cockpit

THE SAE Helicopter Committee is investigating the possibilities of developing desirable criteria for helicopter instruments and cockpit components.

A survey of Committee members brought a variety of comments on what the scope of the project should be. Some felt the work should be confined to instruments peculiar to the helicopter, and to the arrangement of these special and standard instruments to provide maximum pilot aid for both forward flight and hovering. It was also suggested that the type and arrangement of instruments provide for both normal and blind flying.

Choice of type and style of controls and their arrangement emerged as another possible phase of this project. An established practice in this area, it was felt, would insure attention to keeping controls within easy reach, prevent excessive travel and awkward position, and avoid confusing changes from relatively common and acceptable practice.

Help, Not Hindrance

One member noted that while definite standardization of helicopter instrument and control arrangement is not presently possible, suggested choices and arrangements are desirable. He felt any deviations would constitute improvement rather than hazard. If no effort toward standardization is made now, he feared that after large numbers of helicopters go into service, so many variations and individual preferences will have been developed from familiarity with particular arrangements that standardization will be extremely difficult.

Crystallization of a definite program has been assigned to a subcommittee headed by Capt. F. A. Erickson, U. S. Coast Guard. The Committee feels extremely fortunate in securing the service of Capt. Erickson on this project because of his long experience as a helicopter pilot. His group will coordinate its work through R. A. Young, Navy Bureau of Aeronautics, who has been closely associated with the work of the AN Cockpit Standardization Panel on airplane cockpit arrangements.

While taking on this new project, the Committee dropped another—standardization of helicopter hardware parts. It was agreed that this work could be better handled through the National Aeronautics Standards Committee.

The Committee also thanked retiring chairman R. H. Prewitt, Prewitt Aircraft Co., for his untiring efforts in both creating the Committee and maintaining its active program for industry and government. First and only chairman of the Committee since he helped organize it in 1944, Prewitt has stimulated and pushed to completion numerous Committee projects. German helicopter information disseminated by the group and publication of AIR 27, Helicopter Symbols and Formulas, are among the jobs completed under Prewitt's aegis.

J. P. Perry (left) assumes chairmanship of the SAE Helicopter Committee, succeeding R. H. Prewitt (right), who recently resigned

Succeeding Prewitt to the post of Committee chairman is J. P. Perry, Eastern Rotorcraft Co. Perry has been an active member of the SAE Helicopter Committee since its inception. He announced that the next Committee meeting, the first under his chairmanship, will be held next March, in conjunction with the Helicopter Forum of the American Helicopter Society.

Fluids for Hydraulic Torque Converters and Fluid Couplings

SINCE January, 1948, a Subcommittee of the SAE Fuels and Lubricants Technical Committee has been considering the feasibility of establishing a system of viscosity classifications for fluids for hydraulic torque converters and fluid couplings, used either alone or in combination with geared transmissions.

As a result of discussions with the designers and builders of this equipment and also companies supplying fluids for them, the Subcommittee has released the following information which it believes will be of interest not only to users of such equipment, but more especially to those who are working on new designs involving these units.

At present the manufacturers of torque converters for some commercial vehicles and those who build similar units for industrial and contractors equipment differ in their recommendations regarding the fluids to be used in their respective designs. To date it has been impossible to secure agreement between them on a single fluid of sufficiently narrow viscosity range to be covered by one viscosity number, and there appear to be sound technical reasons for the two different fluids specified by them.

Commercially, substantial distribution of these two fluids has been established by the petroleum industry. They have the following viscosity characteristics:

(1) Fluid for torque converters in industrial and contractor's equipment
(Twin Disc Clutch Co.)
Viscosity at 100 F .....
34.4 to 37. 6 sec Saybolt
(2.5 to 3.5 Centistokes)

(2) Fluid for torque converters in commercial vehicles
(GMC Truck & Coach Div., Spicer Division, Dana Corp.)
Viscosity at 100 F .....
60 to 65 sec Saybolt
(10.3 to 11.7 Centistokes)

The petroleum companies are also initiating wide distdibution of a fluid for passenger car automatic transmissions utilizing either torque converters or fluid couplings, which has the following designation and viscosity characteristics:

(3) Automatic Transmission Fluid, Type A
Viscosity at 210 F .....
54 to 56 sec Saybolt
(8.6 to 9.2 Centistokes)

Currently, fluid having essentially these viscosity characteristics is being used in Buick Dynaflow, Cadillac, Lincoln, Nash, Oldsmobile and Pontiac Hydra-Matic and Packard Ultramatic transmissions and will be recommended by Allison Division, General Motors Corporation, for the Allison Torque Converter and Torqmatic semi-automatic transmission used in heavy-duty vehicles for which oil in the SAE 10-10W range is now specified.

To assure satisfactory performance of the fluids in service, the manufacturers using the various viscosity grades defined in (1), (2) and (3) stipulate that they must possess various other important characteristics, including temperature stability, oxidation and corrosion resistance, antifoaming, and special lubricating properties.

Engine oils in the SAE 20-20W and SAE 10-10W ranges are being recommended for torque converters used in commercial vehicles by White Motor Co. and also under normal temperature conditions for fluid couplings made for industrial service by American Blower Co. and Twin Disc Clutch Co.

For the Chrysler fluid coupling, which is entirely separate from the transmission, the manufacturer specifies a fluid in the SAE 10-10W range with special characteristics. This unit is factory filled for the life of the car and requires no attention except in case of accident or other unusual condition.

In connection with the design and development of new equipment using torque converters or fluid couplings, the Subcommittee has called attention to the fact that in the viscosity range below that of the lightest SAE 10-10W oil and above that of the fluid defined in (2) above, there are commercially available and worthy of study, engine oils of approximately 100 sec Saybolt at 100 F having excellent low temperature viscosity characteristics. While no classification has yet been established for them, they are being referred to currently as 5W oils and the viscosity range now proposed for them is 1800 to 3200 sec Saybolt at 0 F. This viscosity grade is being recommended by Twin Disc Clutch Company for some applications of industrial fluid couplings operating under low temperature conditions.

The Subcommittee believes that it would be advantageous in every way for designers to work with fluids in the several ranges mentioned or with oils in the regular SAE Motor Oil Classification ranges, including the proposed 5W range, since all are available commercially. From a performance standpoint, any effects of viscosity differences less than those between the oils and fluids mentioned would be nullified by relatively small changes in temperature. Recommendations of fluids of intermediate viscosity would only complicate distribution and marketing problems for the oil companies, so it is therefore unlikely that they would be made available generally since the volume demand would be so small.

In view of the fact that the SAE Motor Oil Classifications are being studied and may be revised, it appears to the Subcommittee unwise at present to recommend any classification of fluids for hydraulic torque converters or fluid couplings based on the present SAE ranges. However, it is unlikely that any revisions of the Classification would result in changes in the characteristics of the special fluids now recommended and distributed.

Members of the Subcommittee on fluids for torque converters and fluid couplings are: G. A. Round, Socony-Vacuum Oil Co., chairman; A. H. Deimel, Spicer Division, Dana Corp.; H. C. Gooch, Tide Water Associated Oil Co.; J. D. Klinger, Chrysler Corp.; C. J. Livingstone, Gulf Research & Development Co.; J. M. Miller, Standard Oil Co. of Ind.; W. F. Shurts, Twin Disc Clutch Co.; H. R. Wolf, Research Laboratories Division, GMC; R. H. Nelden, American Blower Co.; R. M. Schaefer, Allison Division, GMC; C. W. Georgi, Quaker State Oil Refining Corp.; W. L. Carnegie, Detroit Transmission Division, GMC; H. L. Misch, Packard Motor Car Co.; H. E. Churchill, Studebaker Corp.; B. C. Erickson, Ford Motor Co.; and H. L. Moir, Pure Oil Co.

Technishorts . . . .

COCKPIT STANDARDS: First Meeting of the SAE Cockpit Standardization Committee, S-7, has been called for March by its chairman, M. G. Beard, American Airlines System. Work of the Committee, reports Chairman Beard, will be aimed at standardization of cockpits of commercial aircraft. Serving with Chairman Beard on the Committee are: Art Bussy, Consolidated Vultee Aircraft; M. B. Cahill, Northwest Airlines, Inc.; Carl Christenson, United Air Lines, Inc.; F. E. Davis, Eastern Air Lines, Inc.; Scott Flower, Pan American World Airways System; J. B. Fornasero, Boeing Airplane Co.; Bert Foulds, Douglas Aircraft Co. Inc.; J. B. LeClaire, Transcontinental & Western Air, Inc.; A. P. Shelly, Continental Air Lines; O. E. Tibbs, Glenn L. Martin Co.; and Rudy Thoren, Lockheed Aircraft Corp.

IGNITION RESEARCH: The SAE Ignition Research Committee has been removed from the aegis of the SAE Electrical Equipment Committee and placed directly under the SAE Technical Board, at a recent Board Meeting, to simplify procedure.

TORQUE CONVERTERS: At its first meeting, the SAE Hydraulic Torque Converter Nomenclature Technical Committee set forth as its objective the development of standardized nomenclature, terms, parts, symbols, formulas and charts so that torque converter calculations and tests may be readily analyzed and correlated. The group is considering extending its scope to fluid couplings as well as other devices in the hydrodynamic and hydrostatic fields. Members of the Committee are: R. P. Lewis, Spicer Mfg. Division, Dana Corp., chairman; T. Backus, Fuller Mfg. Co.; R. Brunken, Torcon Corp.; H. E. Churchill, Studebaker Corp.; B. E. Erickson, Ford Motor Co.; J. Jandasek, Chrysler Corp.; V. J. Jandasek, Borg-Warner Corp.; O. K. Kelley, General Motors Corp.; R. Lapsley, Clark Equipment Co.; H. L. Misch and F. R. McFarland, Packard Motor Car Co.; M. M. Schall, Spicer Mfg. Division, Dana Corp.; F. Schick, Allis-Chalmers Mfg. Co.; H. Schneider, Schneider Mfg. Co.; W. F. Shurts, Twin Disc Clutch Co.; D. T. Sicklesteel, Detroit Gear Division, Borg-Warner Corp.; Prof. W. Spannhake, Armour Research Foundation; J. F. Swift, International Harvester Co.; and R. C. Zeidler, Long Mfg. Co.

Journal Index Available

A complete Index covering the twelve 1949 issues (Vol. 57) of the SAE Journal is now available to members and subscribers free upon request.

SAE Section Meetings

Skit Hits Diversity of Control Positions

• Western Michigan Section
R. F. Allison, Field Editor

Dec. 1—The great variety of positions of the manual controls, windshield wiper, lights, starter, ignition key, and so forth, in different makes of cars as compared with the standardization of controls in other types of mechanical equipment in everyday use was brought out in a skit at the annual "Ladies' Night" dinner meeting.

The skit, entitled "Standardization of Manual Controls" (of cars), was conducted as a quiz program by Harold Rosen.

A style show, featuring the latest in fashion, was favorably received by the ladies (and the men).

Also presented was a sound movie of trout and salmon fishing in Alaska. This film was obtained from Nash Motor Co.

Turbojet Engines Have Big Future

• St. Louis Section
G. C. Husbands, Field Editor

Dec. 13—Although increase in power and speed since the use of turbojet engines has been remarkable, future developments will be more outstanding, said **John S. McCarthy,** powerplant technical engineer at McDonnell Aircraft Corp.

Turbojet materials that will withstand higher temperature or some method for cooling the components will allow a more efficient fuel mixture to be used, increasing the horsepower and reducing fuel consumption, he said.

The use of an afterburner described by McCarthy increased the thrust of the turbojet engine by 50%.

A colored film showing the XF-88 (Voodoo) penetration fighter on the ground and in flight was shown. This plane has the turbojet engines mounted low which allows inspection and maintenance while the mechanics stand on the ground. Engine change, accomplished by use of a simple bomb carriage, requires only 15 min.

Vitane In Manifold Suppresses Detonation

• Williamsport Section
R. B. Ingram

Nov. 7—An alcohol-water-tetraethyl lead anti-detonant used through a fully automatic device known as the Vitameter will give octane numbers at costs competitive with refinery methods stated **C. H. Van Hartesveldt,** vice-president of the Thompson-Toledo Vitameter Corp.

Van Hartesveldt further stated that a knocking car detonates only when you "step on the gas" at low rpm, or in other words the part-throttle octane requirements are lower than the full-throttle requirements. The Vitameter furnishes this additional antiknock quality when the engine demands it at—or near full-throttle operating conditions—by the injection of an alcohol-water-tetraethyl lead antidetonant known commercially as Vitane. The flow of Vitane is basically controlled by a shut-off valve located in the Vitameter and actuated by intake manifold pressure.

At high vacuum pressures or part-throttle operating conditions, the valve is closed; whereas, at full-throttle operating conditions and low vacuum pressures ,the valve is opened allowing Vitane to be injected into the intake manifold suppressing detonation.

Van Hartesveldt also pointed out that a differential-control Vitameter is now being tested and may ultimately replace the flange-mounted Vitameter currently used. The differential-control Vitameter uses both engine speed and manifold vacuum to control the injection rate of Vitane and results in a considerable saving of Vitane consumed.

In the discussion session, Van Hartesveldt was asked the reason why the Vitameter was not yet available throughout the country. He replied that several reasons were responsible for this condition. First, it was desired to gain marketing and service operating experience. Second, it was absolutely necessary to be sure that the use of Vitane was not toxic or harmful when handled by service station operators.

Van Hartesveldt assured the group that Vitane is harmless when handled according to instructions and that sufficient service experience has been gained to permit countrywide marketing of the Vitameter and Vitane fluid in the near future.

Western Michigan Section members and their ladies dine together at the annual ladies' night, December 1

Auto Engineering In Europe Discussed

• Baltimore Section
R. L. Ashley, Field Editor

Dec. 8—Fuel economy is uppermost in the minds of European designers and operators. This is reflected by their many ingenious devices to promote fuel economy, said **George A. Round,** chief automotive engineer, Socony-Vacuum Oil Co., as he spoke on new and unusual developments in European automotive engineering in bus, truck, passenger car, and motorcycle fields.

The British have succeeded in obtaining efficiencies and freedom from smoke in the bus diesel field which we have not approached in this country. Round showed how this was done by promoting combustion chamber turbu-

lence by means of shrouded inlet valves, using "squish" type piston design, and underrating engines.

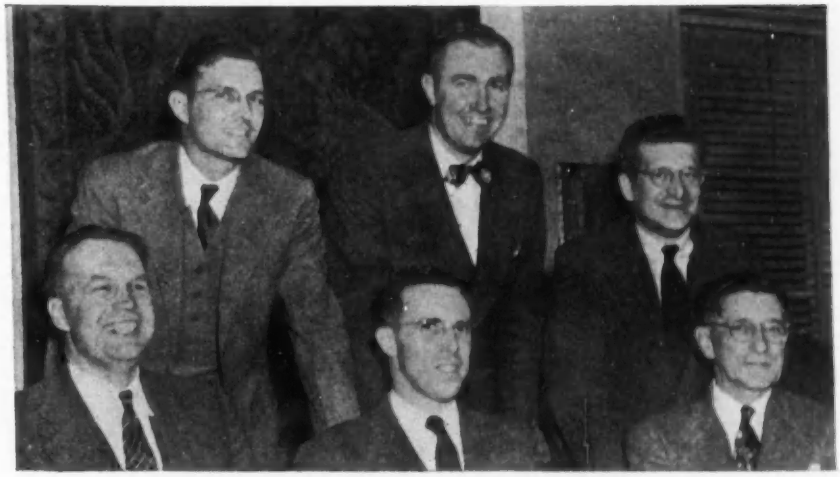
Round also discussed a bicycle engine which runs 600 mpg on gasoline.

Otto Details Latest in Transmissions

• Syracuse Section
L. R. Parkinson, Field Editor

Dec. 19—**Dr. Louis L. Otto,** professor in charge of the automotive engineering course, Cornell University, spoke on "Automatic Transmissions Lead Automotive Developments."

Bringing up to date his last-year paper on automotive transmissions, Otto traced the history of automotive transmissions from the earliest to the most modern.



Syracuse Section's guests were photographed with several of the Section's officers. Left to right: Dr. Louis Otto, the speaker; William Burrows, Aircooled Motors, Inc.; W. H. Lawrence, president of the Syracuse Technology Club; Leslie R. Parkinson, the Section's secretary; Edwin B. Watson, associate professor of mechanical engineering, Cornell University, and Chairman Curtis R. Armbrust of the Section

Military Helicopter Can Transport Troops

• Philadelphia Section
G. B. Calkins, Field Editor

Dec. 14—The U.S. Marines aren't saying they inveted the expression "get there fustest with the mostest" (attributed to Confederate General Bedford Forest); they just think they've found one of the "bestest" ways of doing it—in the military helicopter. According to **Lt.-Col. John F. Carey,** USMC, troop and cargo transport is the coming big job of these unorthodox aircraft. An entire regiment, he estimates, will be able to land in 20 min. That's 3000 men, in wartime.

Carey was introduced by technical chairman Lee Douglas, chief engineer of Piasecki Helicopter Corp., whose big transport craft are being flown at Quantico, Va., to test the new theories.

Before launching into a discussion of his main thesis, "Tactical Uses of the Helicopter," Carey described some of the many present-day military functions of the 'copter. These include air-sea rescue, utility transport, spotting artillery fire from a stable platform which can duck behind cover when necessary, troop reconnaissance, message delivery, wire laying (up to 80 mph!), and as an elevated public address system.

In his view, all of these functions are important, but are overshadowed by the troop-carrying job the helicopters are able to do.

New wars, if they come, will call for wider defensive dispersion than ever; but concentration of overwhelming power is still the only way to win decisive victories. In the business of shuttling men and equipment from place to place rapidly, accurately, and safely, the helicopter seems to fill the bill.

Parachute and glider troops, whose functions the 'copter-borne soldiers may take over, are beset by many serious difficulties, Carey pointed out. Gravest of these is perhaps the loss of "unit integrity" and intercommunication occasioned by the haphazard separation of individuals and groups during the landing process. Equipment is often scattered over miles of territory. And gliding and parachuting are one-way propositions, with no provision for correcting easily-made placement errors. All of these problems, declared Carey, are in some measure solved by the transport helicopter.

To illustrate his ideas, he showed a film taken during operations at Quantico in which "spearhead" troops were landed behind enemy lines to prepare the way for a major amphibious assault. Big helicopters took off from the decks of aircraft carriers many miles at sea and headed landward, looking like swarms of improbable, giant dragonflies, their wings buzzing, their tails held high. Under cover of bombing and artificial smoke, they landed both men and artillery in a matter of seconds. The guns—light field howitzers—were firing less than 3 min after they touched earth. Also demonstrated were ammunition supply and casualty removal operations, both accomplished while the ungainly-looking ships hovered, motionless, a few feet from the ground.

Following the movie a lively discussion ensued, with many questions, largely on technical matters, being fired at the young Marine officer by an ethusiastic audience. His answers revealed some of the Navy's hopes for future vertical-flight machines. They should go as fast as possible, have twin engines for reliability, and carry 15 men—the number in a squad. Larger ships, he told his listeners, wouldn't fit carrier elevators. Rotor gear-box life must be lengthened, he said, from the present 60 hr to at least 300, and without appreciable increase in weight. Some thought is being given to the use of jets on the rotor tips to simplify the whole apparatus, but so far the economy figures are too low. Biggest job is to make the ship inherently stable, and to provide it with instrumentation satisfactory for low-visibility flight, when its attitude is difficult to determine.

Asked if any studies had been made of psychological factors—personnel response to noise and vibration—Carey recalled the remark of one veteran leatherneck non-com after his first flight. Said he, upon stepping out: "Jezz, here I be!"

Automotive Business Good in Europe

• New England Section
J. S. Walker, Ass't Field Editor

Jan. 3—If the European automotive business reflected other business, Europe would succeed in its struggle back to normality said **Glen S. Witham,** Charles Street Garage, in his talk, "International Automobile Exposition at Paris."

Witham has traveled through France, Belgium, Italy, and Switzerland, and regaled his audience with

Helmsmen for the year at the SAE Indiana Section include Warren D. Berkley, vice-chairman, left; Dimitrius Gerdan, the new chairman, and Past-Chairman Raymond Schakel

many witty and shrewd observations of his trip.

He felt we Americans could take a good many lessons from the people of these countries. Witham was impressed by traffic regulation and driver conformity with rules, neatness of the people in play and work, industriousness and the air of hard work everybody showed, and the manner in which roads and their surfaces were kept in good repair as compared with our poorly maintained local streets and highways.

Harry S. Stanton, Boston Globe, was coffee speaker.

Modified B-17 Excels As Flying Test Bed

• Williamsport Group
R. B. Ingram

Dec. 5—"It is axiomatic that an engine can only be considered fully developed after exhaustive testing in a fairly typical installation, operating throughout the range of practical flight requirements," stated **Michael Cervino** in introducing his paper on "Flight Testing of the Wright Typhoon Turboprop Engine in a B-17 Bomber." Recognition of this fact led Wright Aeronautical Corp. and the USAF jointly to sponsor an extensive program for developing and testing a flight installation of the WAC turboprop engine in a B-17 modified to serve as a flying test bed.

The prime objectives of this program were to:

a. Prepare a suitable flight test vehicle for extensive prototype testing of the large WAC turboprop models.

b. Obtain engine characteristics under actual ground and flight operating conditions.

c. Establish powerplant installation design requirements with specific regard to good practice for turboprop type engines.

Cervino discussed the execution of this program and the results obtained by appropriate photographs, charts, and moving pictures of the Wright Typhoon engine in flight.

In conclusion Cervino stated that the modified B-17 airplane with nose mounted turboprop test engine installation provides a highly successful flight test vehicle in terms of operating flexibility, roominess, and safety. The fifth-engine arrangement as now constituted in the B-17 is readily adaptable to a wide range of engine types, both reciprocating and nonreciprocating. It thus represents the closest possible approach to an all-purpose test airplane for engine development work.

In the discussion session, Cervino was asked about the ease of starting the Wright Typhoon. He replied that all starts were very smooth with no evidence of any flaming or smoking in the tailpipe during starting. In flight, the exhaust gases were also very clean.

Some Favor Diesel Over Otto Engine

• Northwest Section
Kenneth A. Short, Field Editor

Dec. 9—The extreme, toolroom-like accuracies of manufacture necessitated by the high pressures involved and the exact metering of fuel required, cause the cost of producing the pump and injection system for the diesel to exceed the total cost of producing a fairly good sized otto engine, declared **Fred B. Lautzenhiser.**

Consulting engineer of the motor truck division of International Harvester Co., Lautzenhiser presented his paper, "Diesel versus Gasoline Powerplants in Motor Trucks."

Besides presenting his paper, Lautzenhiser explained the need for uniformity of load-bearing capacity of bridges and highways, as well as for uniform legal limitations on lengths, widths, and gross weights of highway vehicles. In legislative thinking, he said, there are trends toward levying taxes on the ton-mile basis and establishing minimum-performance requirements for trucks.

The concensus of opinion, during the discussion period, favored the diesel engine.

Central Illinois Hears 3 of Its Own Members

• Central Illinois
Ivan Lamport, Field Editor

Nov. 21—"Would you believe that $10,000 would not buy much in the way of a field test?" asked **Frank A. Grooss,** staff engineer at Caterpillar Tractor Co.

Each year corporations appropriate large sums of money in order to carry on experimental work outside the confines of their physical plant facilities. The amount of money spent for this field testing of experimental and preproduction machines or machine components varies with the product and company, he said.

One field test conducted over a period of about two years cost over a half million dollars.

Field testing compares cost-wise with laboratory work, and in the final analysis, field testing under actual job conditions is one of the more certain ways of assuring yourself that your product is ready for the production line, concluded Grooss.

Second on this program of "local talent" was **T. M. Fahnestock,** manager of service engineering at Caterpillar, who outlined the Service Department at his company.

A manufacturer's responsibility is not limited to designing and building the best products for a particular need or market, said Fahnestock. Further steps must be taken to insure that the necessary repair facilities are made available to enable the customer to get the maximum return on his investment through the continuous use of his equipment. Repair facilities include not only the "know how" but also an ample supply of parts.

The Service Department at Caterpillar, Fahnestock said, is divided into field contact and staff divisions.

The field contact divisions handle all

correspondence with distributors pertaining to product improvement, inquiries on various modifications, service tools, and claims.

Under the staff division are:

1. Service Publications—prepares the operator's instruction books for all major products and attachments.

2. Service Development — trains Caterpillar service representatives, distributors' service managers, and distributors' servicemen, in the maintenance of equipment in the field.

3. Service Engineering—continually reviews the performance of machinery in the field.

Closing the program of speakers, **H. W. Fall** supervisor, research department at Caterpillar, explained that experimental stress analysis as practiced in industry today involves (1) determination of operating stresses in a part or assembly and (2) evaluation of the effect of these stresses.

The stresses are determined from measurements of very minute deformations. The proper evaluation may be made of these stresses from data already available on a material or by fatigue tests when the occasion demands. Fall declared that intelligent use of these methods enables a manufacturer to give a customer more value for his dollars and to remain in a favorable position with his competitors.

PM Program Is Key To Good Performance

• Buffalo Section
Ben Fuente, Field Editor

Dec. 15—Wherever mechanical men get together the question of performance of their respective fleets always crops up, stated **William W. Kunz,** superintendent of equipment for International Railway Co. The methods of measuring that performance are as varied as there are fleets.

In describing the preventive maintenance program of his company, Kunz said they have adopted the following definition of a "pull-in" insofar as their performance records are concerned.

"Any vehicle which, for any reason whatsoever, does not complete the work assigned to it on pulling out of the garage shall be considered a pull-in."

Obviously, with such a broad definition of a pull-in it is essential that a careful analysis be made of these real and apparent failures in order to place responsibility for their occurrence on the proper individuals.

The analysis of pull-ins in which the breakdown of mechanical equipment is the cause of actual delays, is the one that IRC wants to eliminate because it causes the most direct inconvenience to passengers. This type of failure has been brought down to involve less

25 Years Ago

Facts and Opinions from SAE Journal of February, 1925

The "ring" or "tinny" sound credited generally to an all-metal body has been exaggerated, E. G. Budd argued at the Annual Meeting. He said there is no more thin sheet metal in an all-metal body than in a wood-frame body. Although the outer shell is somewhat heavier, it is formed in a manner that stiffens it and eliminates the noise that people like to designate as "tinny".

■

C. E. Summers' presentation of his paper, entitled "Measurement of Engine Vibration Phenomena," constituted one of the hits of the whole Annual Meeting. . . . The most striking thing about Mr. Summers' address was the demonstrations of running apparatus.

■

R. B. Day of Goodyear reiterated his belief that "shimmying cannot be corrected by changing the design of the tire, nor can high pressure give a correction that will be readily acceptable to a driver who desires the comfort of low-pressure air. The answer is to be found in the mechanical features that control the tires."

■

W. R. Strickland reached the conclusion that low pressures and thin side walls of balloon tires are the chief causes of shimmy and that no acceptable changes in chassis design can be made to control it. He suggested use of a moderate design of balloon tire, not too thin a side wall, proper width of rim, and medium air-pressure.

■

"The balloon tire is the third important step in tire history. . . . It is no discredit today to admit lack of finality in what has been accomplished in the balloon tire. . . . The spread of the balloon tire idea created a healthy commotion in automobile and tire fields. . . . The tire makers were like the suburbanite caught up in the Christmas crowds who had spilled a basket of miscellaneous presents and was trying to gather them up and at the same time not get left in the onward rush. Some caught the first train home carrying only a few of their high-pressure-tire tricks. Others carried along all their past experiences, but caught a later train. The most successful took what they could comfortably carry, but not so many as to impede steady progress toward an ultimate goal."—B. J. Lemon at Annual Meeting in "Glimpses of Balloon Tire Progress."

■

Installation of Student Branches of the Society was favorably discussed at a Sections Committee meeting this month. Attention was called to the fact that a number of engineering institutions are even insistent in their demands that the Society's work be expanded to include this activity. Work now in progress should soon result in the formulation of definite plans concerning this proposed extension of the Society's services.

■

L. C. Hill, who for several years has been assistant general manager of the society, left its service this month to go into sales engineering work for Valentine & Co., with headquarters in Detroit. John A. C. Warner, who latterly was manager of the Research Department of the Society, has been placed in charge of the Meetings and Sections Department, in succession to Mr. Hill.

■

Advantages of 6-wheel over 4-wheel trucks, according to Ethelbert Favary include: reduced load on each wheel, reduced impact forces, improved traction, and reduced tendencies toward wheel-spinning and skidding. . . . Also, increased economy in freight transportation, and a smaler number of trucks on the road to carry the same amount of tonnage.

■

Speakers at SAE Section meetings this month included: Charles F. Kettering (Dayton), Herbert Chase (New England), John Younger (Pennsylvania), F. E. Chandler (Washington), J. H. Hunt (Cleveland), L. M. Woolson (Buffalo), H. H. Allen (Metropolitan), H. C. Mougey (Indiana), Prof. A. H. Hoffman (San Francisco), Joseph Scott and W. F. Fairbank (Los Angeles).

■

Twenty-seven million automobiles is the new saturation point set by Col. Leonard P. Ayres, vice-president of Cleveland Trust Co., in his speech at the 1925 Anual Dinner in New York, Jan. 8. "There are 17,000,000 motor vehicles now in use," he said, "so there are still plenty of opportunities for salesmanship."

Student Section members of Oregon State College who had just inspected the U. S. Bonneville Power Administration's test panel and one of three features of their field trip

than 3% of the equipment operated.

Kunz said that the average passenger riding on an IRC bus can expect to ride approximately 5000 miles without experiencing any inconvenience due to mechanical breakdown.

Kunz concluded by saying that their preventive maintenance inspection systems call for the inspection or adjustment of over 1,600,000 major items per year of 2400 per bus per year, a failure on any one of which might cause a breakdown, and they get a performance record of 97% perfection.

"Rotor-matic" Allows Hands-off Flying

• Northern California Section
Avon Brown, Field Editor

Dec. 12—A field trip to the United Helicopters, Inc. plant in Palo Alto, Calif., with many members flying for the first time in a rotary wing aircraft was featured at this meeting.

The Hiller 360 is the first helicopter on the Pacific Coast to be issued a type certificate by the CAA.

Basic design consists of a spoon-shaped open-cockpit fuselage suspended from the vertical engine which is in turn suspended from the rotor. Outstanding feature of the craft is the patented "Rotor-matic" control which, added to the inherent stability of the craft, allows hands-off flying. Test pilots flew the ship from Palo Alto to San Francisco while riding on the landing gear braces. Aerial movies showed that the unique overhead control stick was not lashed and was untouched.

After the plant visit, **Langhorne Washburne** of United Helicopters, Inc., gave a short talk and showed movies of helicopters built during the past nine years by Stanley Hiller, Jr., who is president of the company.

Building his first flying model helicopter at the age of 14, Hiller successfully flew the world's first co-axial helicopter at 19 in 1944.

The secret of the Rotor-matic control, according to Washburne, is in the control rotors, a pair of paddle-like airfoils which are mounted at right angles to the main rotors and swing in a circle of about 8 ft diameter. The pilot flies the control rotors, which by their aerodynamic characteristics act as servo-controls for the main rotors, which swing in a 35 deg circle.

Torque compensation is supplied by a tail rotor supported by a tubular monocoque boom and driven by a universal-jointed shaft from the engine transmission.

The transmission is simple, having only a single planetary reduction gear and an automatic mercury clutch.

To date the total production is devoted to working helicopters. Besides the more newsworthy function as an ambulance or rescue ship, helicopters serve for crop dusting and spraying, tuna locating, and high-tension line inspection, Washburne said in concluding his talk.

Taxes Increase on Diesel Trucks

• Spokane-Intermountain Section
R. N. Williams, Field Editor

Dec. 16—Both diesel and gasoline engines have their limitations for trucks at the present time. Usually it is quite obvious which engine will be the more economical for a particular application, concluded **Fred B. Lautzenhiser.**

Lautzenhiser, who is consulting engineer of the motor truck division of International Harvester presented his paper, "Diesel versus Gasoline Powerplants in Motor Trucks."

Discussion following the presentation brought out that in general a diesel engine must drive its truck 60,000 miles per year to be profitable. This mileage figure reflects the additional installation costs and the increasing taxes on diesel trucks.

It was pointed out also that the future of diesel engines on the highway is questionable due to the tendency of the states to increase taxes on diesel trucks and their fuel.

Much Research Needed On Guided Missiles

• Southern California Section
R. E. Strasser, Field Editor

Dec. 1—Each type of guided missile, air to air, ground to air, air to ground, and ground to ground, has its own problems. Common problem of all is guidance, said **Dr. Howard Seifert,** chief of the applied physics division, Jet Propulsion Laboratory, California Institute of Technology.

The speed and flying altitude of modern aircraft make air to air and ground to air missiles the most difficult to guide. He said any device must be automatic with instantaneous reactions.

The available types of thrust producing devices in order of increasing complexity and flight duration but decreasing rate of fuel consumption are: solid propellant rockets, liquid propellant rockets, ramjets, pulsejets, and turbojets. The aerodynamic problems include lift and drag, stability, skin friction, jet vanes, dispersion, body configuration, and structures.

Seifert pointed out that types of guidance include, command (2 radar computer), beam rider (1 radar, several missiles), homing (seeker in missile) navigational autopilot. All of these use radar or electronic devices, and as the guidance unit of the missile can weigh only 50 lb a great deal of miniaturization must take place.

Thus the problem of guided missiles is a vast one, on which much research and development is still to be done, concluded Seifert.

Transmission Trend Gaining

• Southern New England Section
Robert E. Johansson, Field Editor

Dec. 7—Within two years at the latest, every automobile manufacturer in the United States will offer some form of automatic transmission to the public, and the torque converter type will dominate the field. This was predicted

by **Joseph Geschelin**, Detroit editor of "Automotive Industries."

Furthermore, price reductions, such as recently announced for the Hydra-matic and Dynaflow transmissions, will result as volume production figures increase, he said. Increased volume is the chief cause of current price reductions; however, improved production engineering and design refinement will undoubtedly figure prominently in this trend.

The present state of the automatic transmission art is primarily due to the general desire to eliminate the clutch. A brief historical resume by Geschelin emphasized this fact. One of the oldest approaches to this problem is the overdrive mechanism. Its popularity is evidenced by the fact that up to last year, Borg-Warner had produced more than 3,000,000 overdrive units. At this point, it was noted that the combination of overdrive and the conventional transmission still leads the field for fuel economy. It is the economy of this combination that has been set as the goal still to be attained by any existing automatic transmission.

Geschelin's answer to those who ask why it has taken so long to get automatic transmissions of the market, is the tremendous cost of development and tooling. For example, Buick, one of the pioneers in this field, has spent over $20,000,000 to date for this purpose. Of course, other manufacturers have been able to profit by the efforts of the pioneers who have had to do the job the hard way. Packard, which has spent some $7,000,000 to date, has benefitted greatly from improved production engineering. Chevrolet, which will announce a new transmission shortly, has been able to draw from past experience and will incorporate many amazing adaptations of their own production engineering and design features.

Whatever the type may be, there are certain general requirements to be met by any automatic transmission, the speaker said.

1. The transmission must be completely automatic, but always under the driver's control. The driver must still be able to operate manually a selector which sets the master valve, and starts the desired ensuing chain of events. Every type furnishes this with the exception of the Hydramatic.

2. There must be a safe control of speed on downgrades. Despite controversy on this issue, Geschelin's opinion was that all types should be fairly safe in this respect in the low range of operation.

3. Smoothness of operation is essential. The forthcoming Studebaker transmission is said to be capable of shifting from direct drive to low range without shock to car or passenger.

4. The ability to "rock" the car is essential when bogged down in snow or mud. The Hydramatic does not include this feature. The new Ford transmission control positions the "reverse" and "low" range stops adjacent to each other to facilitate rocking.

5. The ability to start the car by pushing is important. The present range of pushing speeds extends from 12 to 35 mph.

6. All the types have compulsory "kickdown" for acceleration in high range.

7. Creep control. Most types have been troubled by creep; however, Studebaker has approached the problem from a different angle. Instead of reducing inherent creep, they have provided a "no-creep" device which automatically sets the brake system. When forward motion is again initiated by pressure on the accelerator, electric controls release the brake and other controls of the idle jet also come into play. This is somewhat similar to the action of the famous "hill holder." Studebaker will rename the latter as a "no-roll" device.

8. The ability to start only in neutral or parking positions solved by Ford, who has placed the "park" and "reverse" stops on their manual control adjacent to each other so as to cover the most general sequence requirement.

9. All types accomplish parking lock without the use of the brakes except Studebaker which uses the brake automatically through the "no-creep" device. Hydramatic's "reverse" position accomplishes the same result.

10. Fuel economy is important and all types are striving to accomplish the standard set by combination of standard transmission and overdrive.

Geschelin said that Studebaker will have a torque converter, mechanical clutch, and 3-speed transmission. Ford will have a torque converter and 3-speed gear box.

Studebaker's torque converter is unique inasmuch as it is entirely made up of stampings which are not brazed or welded in assembly. All assemblies are accomplished with staking and the use of tabs. Studebaker has also eliminated the hazard of accidental tripping of the reverase switch when moving forward along the road. If this does accidentally occur, the transmission, through the use of interlocks, goes into neutral.

The most complex mechanism to date is the Dynaflow, but the Studebaker has more gadgets designed to duplicate the human habits of the driver. As any type tries to approach

Journal Index Available

A complete Index covering the twelve 1949 issues (Vol. 57) of the SAE Journal is now available to members and subscribers free upon request.

You'll be interested to know . . . .

GENERAL CHAIRMEN for five 1950 SAE National Meetings were named by SAE Council at its January 13 meeting. L. S. Pfost, chief engineer, Massey-Harris Co., is to be general chairman of the Tractor Meeting; E. C. Sulzman, sales manager, Wright Aeronautical Corp., of the Aeronautic Meeting (New York); T. L. Preble, supervisor, automotive transportation, Tide Water Associated Oil Co., of the Transportation Meeting; and Reagan C. Stunkel, president, Aviation Maintenance Corp., of the Aeronautic Meeting (Los Angeles).

NEW CHAIRMAN OF THE SAE DAVID BEECROFT Traffic Engineering Committee is SAE Past-President J. M. Crawford, vice-president of engineering, General Motors Corp. Crawford succeeds Pyke Johnson, president, Automotive Safety Foundation, in this post which Johnson has filled since inauguration of the Committee in 1946. . . . The Committee, which recommends to the SAE Past-Presidents Committee each year a candidate to deliver the Beecroft Memorial Lecture, is composed of representatives chosen by seven organizations interested in the traffic safety movement. The chairman is the SAE representative.

COUPONS FOR CONVENIENCE (See p. 22 and p. 100, December issue) started to sell soon after SAE Journal for December reached readers. First to buy one of the new coupon books ($5 worth of coupons for $4.60 for buying SAE papers and Special Publications) was Dr. F. C. Reggio, consulting engineer of Norwalk, Conn. . . . and he was the first one to spend a coupon, too.

more closely the traits of the human mind, the mechanism will become more complex, Geschelin said.

The torque multiplication for the various models is as follows:

Ford	2.00 to 1.00
Studebaker	2.15 to 1.00
Packard	2.40 to 1.00
Buick	2.25 to 1.00

During the question period, it was brought out that at least 5% slip is to be expected despite claims to contrary. Furthermore, an unnamed manufacturer who has made automatic transmissions standard equipment in the past will reverse this practice and offer it as optional equipment. Chrysler will undoubtedly come out with something new, although their "security on news" rivals that of the Atomic Energy Commission, Geschelin said.

In closing, Geschelin reiterated that the next big steps will be in design refinement and improved production engineering such as Chevrolet will demonstrate. Intensive research is going on continuously, and the costs of future transmissions will definitely be lower than today's automatic due to high volume production.

Good Brakes Important In Vehicle Design

• Kansas City Section
K. J. Holloway, Field Editor

Dec. 12—Safe vehicle operation depends more on satisfactory brakes than on any other single element of vehicle design, stated **Paul J. Reese,** automotive application engineer, Wagner Electric Corp., in presenting his paper, "Automotive Brake Problems."

The functions of the brake system are to reduce speed, stop the vehicle, and hold it at rest. Reese said the basic elements involved in the performance of these functions are capacity of brakes, physical limitations of driver, and the character of the surface of the road and tires.

Skidding of the wheels is the factor which limits the torque which can be applied to stop the vehicle. In this connection, the skidding coefficient varies with speed and may be as high as unity at low speed but decreases with an increase in speed to about 0.6 at highway driving speeds. Maximum deceleration is therefore limited to about 20 ft per sec per sec, he said.

Reese pointed out that the percentage of braking on the front wheels of the first four wheel brake installation was limited to about 35% while on some of the late model cars this has increased to about 65%. The present tren dof automobile design toward inthe transfer of weight to the front wheels during deceleration has necessicreased weight on the front wheels plus tated this ratio of brake distribution to maintain brake performance.

Passenger comfort must also be considered and normally dictates the most commonly used rates of deceleration, stated Reese. Deceleration greater than 16 ft per sec per sec tends to throw passengers out of their seats while for standing bus passengers decelerations greater than 12 ft per sec per sec are objectionable.

To emphasize the severe conditions imposed on components of the brake system during deceleration, Reese pointed out that the kinetic energy of a smaller low priced car traveling at maximum speed is approximately 800,000 ft-lb (heat equivalent is 1050 Btu) and for larger faster cars, the kinetic energy when traveling at maximum speed is over 1,500,000 ft-lb (heat equivalent is 1925 Btu). Metallurgists estimate that 1925 Btu will melt a cube of iron 2⅜ sq in. weighing 3½ lb.

Concluding, Reese said kinetic energy must be transformed to heat energy by friction between the brake drums and brake lining during deceleration. About 75% of this heat is generated during this first half of deceleration. Brake drums have been kown to develop temperatures as high as 1400–1500 F during severe service.

At the conclusion of Reese's talk, a film entitled "New Champions of Transportation," depicting the development of new models of International Harvester trucks was shown.

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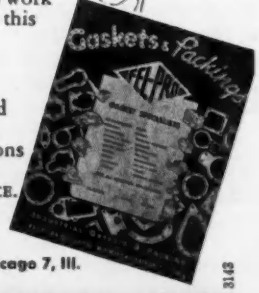

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• Mohawk-Hudson Group
Frank Baker, Field Editor

Nov. 16—Out of 12 years of experience with torque converters in buses, General Motors has evolved a new hydraulic transmission, possessing many improvements, **Henry Hickman,** GMC regional service manager showed.

Since the development of the Smith-Lysholm torque converter which was incorporated in standard GMC buses in

1937, engineers of General Motors have been considering improvements from the maintenance and cost point of view, Hickman explained. With these things in mind they started anew two years ago to develop an "ideal torque converter"—one giving best performance, greatest accessibility, minimum cost, and minimum weight.

Since modern bus construction dictates the transverse mounting of the engine in rear of the driving axle, the transmission is set with an angle of 63 deg between the axle of the engine crankshaft and the axis of the transmission. Every attempt was made to eliminate parasitic losses in the transmission which would lower the efficiency of the unit. As a result the efficiency curve reaches a maximum at 30 mph and has a flat characteristic, whereas the efficiency of the earlier model peaked at 25 mph decreased rapidly.

All parts not required during power transmission are either allowed to float free by means of a free-wheeling clutch or are completely disengaged. When the unit is in direct drive, the entire hydraulic turbine is free wheeling. In the latter category is the reverse idler layshaft which is dormant except when the bus is in reverse, Hickman said.

From experimental data it was found that a two-stage radial converter was the most practical arrangement to use. It was also decided to make the unit as independent as possible from the engine. To do so, an independent lubrication system was devised which uses a special hydraulic fluid developed for this transmission. Earlier designs used diesel fuel oil, which was returned to the fuel tank. Another earlier design used engine oil which was delivered to the turbine by a special engine-driven pump. However these two systems were not satisfactory. The new system is completely sealed from road dirt and all leakage is internal and used as means of lubrication. The oil, which is circulated in a closed system, is removed from the vicinity of the turning elements to reduce churning and to remove excess heat to the cooler. Since dirt and excessive heat are the main causes of clutch wear, the life of the clutch is greatly increased, according to the speaker.

The fluid system of the transmission has a three-stage pump. The first stage delivers the fluid to the center of the torque converter at 35 psi; the second stage delivers oil to drilled passages to spray oil on moving parts for lubrication and cooling. Oil is sprayed on the gears as they end engagement, since it has been found that this cools them more readily and reduces scuffing. The third stage is a scavenge pump which keeps the oil level at a minimum to reduce churning. The pressure differential in any part of the system does not exceed 20 psi. To cool the fluid, it passes through a three-pass seven-row radiator which is mounted as far as possible from the transmission to allow for long hose connections, which will permit maximum movement between the powerplant and transmission. The maximum temperature rarely exceeds 180 F.

All shifting is done automatically by a clutch which is actuated by an air cylinder. To shift the transmission from "hydraulic" to "direct drive," a clutch disc is actuated by a pair of Bellville washer springs which are positive in their action to eliminate slippage. On standard bus installations, the drive changes from hydraulic drive to straight mechanical drive on acceleration from a standing start at 24 mph. On deceleration the shift from direct drive to hydraulic occurs at 17 mph. However, if the terrain over which the bus operates warrants, these points of shifting may be changed, Hickman said. This drive can also be adapted to gasoline engines by changing the gear ratio. For the diesel engine application the engine-to-turbine ratio is 1.04. For a gasoline engine the

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ration is 1.24 to compensate for the torque characteristics of the latter engine.

The discussion revealed that this type of transmission has been operated without overhaul for over 200,000 miles.

Bus Travel Gains, Diesel Use Mounts

• Detroit Section

Ruth and John DeWald, Asst. Field Editors

Dec. 5—Thirty million people in the U. S. do not have access to automobiles, and half of the people transported to cities make use of intercity bus lines, said **Milo M. Dean**, chief engineer of Greyhound Bus Lines.

Greyhound carried 210 million passengers (150% of the population of the U. S.) nearly 6 million bus miles in 1948. About 88 million gallons of fuel were consumed in driving 500 million bus miles, 53% of which were diesel-powered. An average of 4.7 miles per gallon were obtained with gasoline as against 6.56 miles per gallon with diesel fuel.

Gasoline engines provided 30 ton mpg, while diesel engines gave 85 ton mpg.

Emphasis has been placed on the use of diesels in buses during the war and since, and it has been found that maintenance is just as easy as with gasoline engines. Engine overhauling has been standardized at 60,000 miles or 2000 hr, with major overhaul every 400 hr. Mechanical units are overhauled each 120,000 miles. Brake drum life has been determined at 200,000 miles. Because there is little room for air cooling brakes, the energy is absorbed and stored within the large mass of the cast iron drum. Brake linings show a life of from 35,000 to 65,000 miles, depending on service.

Aircooled engines are under experimental installation and of interest to the bus companies because 21% of engine failures are caused by cooling difficulties. No overheating has been experienced during the summer with the four engines under operating test, but trouble is encountered in winter in keeping the aircooled engines warm enough.

At present the heat from the liquid cooling system on engines is used to warm the air inside the bus. This would no longer be available, if liquid-cooled engines were discarded. This condition would cause problems, since air-to-air heating is unlawful.

Dean pointed out that, while his company does not own its tires, it does inspect them. The tires are rented on a fee basis; when the tread is worn smooth, the tires are regrooved. Retreads have not proved practical, and no tire is driven after the fabric wears through the rubber covering.

For better wheel and tire alignment, aluminum disk wheels are used. They have demonstrated a life of 175,000 miles. The weight saved is about half, since the aluminum wheel weighs 45 lb, compared with an equivalent steel wheel weight of 97 lb. The hub is also made of aluminum.

The transmission used on the standard bus is a four-speed, nonsynchronized gear box having a life of from 175,000 to 225,000 miles. Torque converters are considered too expensive for present installation, since the fuel economy would be poor on long grades. Axle gear life has been established as averaging 225,000 miles. The usual axle ratio used is 3 5/9, but a 4 1/8 ratio is used for hilly terrain. Because of the legal load limit of 18,000 lb per axle, it has become necessary to install a third, or load, axle in front of the driving axle on the newest bus, the Scenicruiser. This third axle is so mounted that interference vibrations are set up to cancel out those incurred by the separately suspended driving axle.

The scenicruiser is 40 ft long, 11 ft high at the rear, 96 in. wide, and carries 43 passengers. It also has air-conditioning, hydraulic steering and brakes, two-way phone communication, a wire recorder to entertain passengers, an observation lounge, and a lavatory.

Glass roof panels are chrome plated so that only about 8% of the heat energy is admitted, but maximum light is obtained. The side windows are of special glass containing a vinyl plastic which is dyed so that it absorbs all but 6% of the visible light at the top and 65% at the bottom of the window. Curtains are thus eliminated.

The body is designed so that all stresses are carried by a truss structure of SAE 4130 steel running the length of the bus above the wheels and between the windows. The roof is supported by three main posts, welded to the truss. A small column carries the rear axles. The air in the bus is changed every 40 sec at the rate of 2400 cfm with an expenditure of 0.3 hp of electric power at 42 amp and 14 v. The floor is maintained at 72 F and the walls at 82 F for an interior temperature of 74 F. Two thermostats automatically control the air conditioning and admit fresh air to the system.

R. W. Budd, president of Great Lakes Greyhound Lines, was one of the discussions of Dean's paper. He pointed out that manufacturing improvements allow 150,000 miles before major overhaul of gasoline engines, and 200,000

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for diesels. His company transported 43 million passengers in 1948 with 600 suburban and intercity buses. The organization of the company consists of four major divisions: maintenance, operation, traffic and accounting.

Maintenance is responsible for estimating mileage and cost per mile as well as keeping equipment in repair. Operation cares for personnel, as well as making the wheels revolve. The traffic department controls services. Accounting finds out how the rest of the departments spent their money.

Additional sections on sudden-demand routes, charter services, Willow Run Airport, and the horseracing schedules at the Fair Grounds, Detroit, must all be met. Unexpected increase in rural pick-ups can now be reported and accommodated by two-way phone communications. At present this telephone network extends beyond Bay City, Mich. and will soon reach Sault Ste. Marie.

Budd concluded by comparing the industry with its status of 10 years ago. Mileage increased from 181 million to 500 million, total revenue from $50 million to $192 million, buses from 2800 to 5800, but dividends dropped off from $2.05 per share of stock to $1.70 per share.

Another commentator, W. B. Oakley, of Detroit Diesel Division, General Motors Corp., illustrated the progress of his company's engines since 1938, when their life was about 25,000 miles at 150 to 160 bhp with a weight of 12.5 lb per hp. Today's engine of 220 bhp has a life of 200,000 miles with an experimental weight of 6.7 lb per hp. Oakley could see possibilities of even further reduction to a weight of 5.5 lb per hp, and concluded that engine life and horsepower will continue to increase while the weight of the engine will tend to decrease in the future.

Great Britain Leads U. S. in Jet Design

• Metropolitan Section
John Waugh, Field Editor

Dec. 15—**Great Britain has an unquestioned lead over the U. S. in jet-powered airline transport design, but it is a lead which may contribute the experience needed to make forthcoming U. S. jet designs eventually superior, declared William Littlewood, vice-president of engineering at American Airlines.**

Littlewood, who recently examined the latest British jet transports in England, said that American aircraft designers have already profited from British experience and have not frozen their designs as have the British in their attempt to get jet transports on the market in a hurry.

Although British engineers were probably aware of the hazards of freezing designs while developmental changes were occurring so rapidly, pressing economic factors were probably the cause, said Littlewood.

Advantages of jet transport travel, said Littlewood, are speed; smooth, vibration-free travel comfort; and simplicity in design, construction, maintenance, and operation. Disadvantages apparent in present designs are high fuel consumption of the turbine engine and poor performance at low speeds and low altitudes. Stacking of jet transports over congested airports would not be possible because of these limitations. Jets would require almost immediate clearance.

Littlewood concluded that American designers are faced with a huge and complex program, costing great amounts of time, money, energy, brains, and most importantly, cooperation.

Many Problems Faced In Customer Relations

• Baltimore Section
R. L. Ashley, Field Editor

Jan. 12—The problems faced in dealing with customers were discussed by **T. L. Taylor,** director of customer relations at Glenn L. Martin Co.

During the 1930's Taylor worked with the Chinese Air Force in China, and many of the problems he encountered there were of similar nature to those which he encounters in his work today, he related.

In concluding, Taylor said that customer relations are very little or no different than human relations and human relations are forever complex.

Jet Engines Explained At SAE-IAS Meeting

• Dayton Section
T. O. Mathues, Field Editor

Dec. 20—**Major-Gen. Laurence C. Craigie,** commandant USAF Institute of Technology, spoke at a joint meeting of the Dayton Section of SAE and the Institute of Aeronautical Sciences. Gen. Craigie's theme, "Modern Systems of Aircraft Propulsion" explained the operating principles and historical evolution of both jet and rocket aircraft engines.

A Walt Disney colored film, originally developed by the Air Force to be shown to prospective jet plane pilots, explained the basic mechanics of the turbojet engine.

A series of slides depicted the evo-

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lution of the jet engine from Hero's "Heleopile" (100 B.C.), to Air Commodore Sir Frank Whittle's first successful turbojet engine (1941).

The meeting was concluded with an Air Force film showing the test flights of many unusual experimental jet planes. Also shown in the film was the use of both solid and liquid fuel rockets for assisting take-offs of both jet and reciprocating engine planes.

Buffalo-Springfield Exhibits Antique Cars

• Dayton Section
T. O. Mathues, Field Editor

Nov. 10—Highlight of this meeting was an antique automobile show held at the Buffalo-Springfield Roller Co.

There were 15 cars on display, the oldest being a 1901 curved dash Oldsmobile owned by C. F. Greiner. He also displayed his 1906 Stanley Steamer, 1906 Reo, 1912 Pierce Arrow, 1920 Mercer Raceabout, and 1922 Mercer Touring. J. F. Harrison showed his 1911 Hupmobile, and Roy Free his 1912 Packard, 1913 Ford, and 1924 Loucia. The newest car was a 1948 MG Roadster, displayed by E. E. Greiner, who also showed his 1922 Rolls Royce, 1924 Hispano-Suiza, and 1928 Rolls Royce. F. H. Miller displayed his 1913 American Underslung Traveler.

All automobiles were in operating condition except the curved dash Olds and the Stanley Steamer.

Murray D. Shaffer, director of sales for Buffalo-Springfield Roller Co., informed the group about the history and products of his company.

Major **E. E. Greiner**, executive vice-president of Buffalo-Springfield, related some of his experiences on the 1928 King Alphonso Yacht Cup Race from New York to Spain.

Student News

Oklahoma A & M College

Almost no engines are troublefree, said Franklin E. DeVore, fleet engineer for the Ethyl Corp., who went on to prove his contention.

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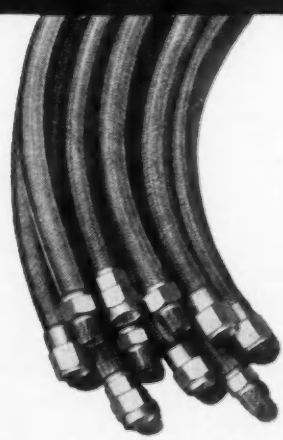

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Complaints are often due to engine modifications, new applications, or freak causes. Storage of gasoline for too long a time or under improper conditions may cause gum formation. Maladjustments may cause improper functioning of any of the five main circuits in a carburetor. For good economy, the idle circuit should be set slightly lean. Operation with the main or power circuits too lean may cause valve failure, DeVore said.

The valves of an engine are the most abused part. Improper seating of the valve may cause overheating. Excessive heat in valves causes, among other things, stem erosion, dishing of valve heads, and erosion of valve faces. The bore of the valve guide should not be beveled, since one of its important functions is to serve as a scraper for the valve stem. Some valves are susceptible to rust. Very dirty intake air causes a characteristic erosion of the intake valve faces. Valve rotators serve a good purpose in almost every application, according to the speaker.

The ignition system is a major source of complaint. Worn parts or inaccurate parts may fail to give equal spark timing on all cylinders. Improper spring tension in the spark advance will not give correct spark timing as the speed changes, DeVore said.

—F. L. Pryor

California State Polytechnic College

The "upside down system" of education is characterized by the grouping of as many technical and job-getting courses in the first two years as possible, explained Charles E. Knott, head of the engineering division.

Members were told that California Polytechnic places major emphasis on instruction rather than on research through the application of a "learn by doing" philosophy. It was further stated by Knott that the purpose of the college is to prepare the graduate for his first job with the feeling that he will gain promotion through his own initiative.

In telling of future expansion of the school, the speaker said that a contract has been let for the drawing of plans for a $1½ million engineering building to be built soon.

Also featured at the meeting was the showing of films entitled "Resistance Welding" and "Principles of Gearing."

—D. H. Garner

College of the City of New York

Forty students visited the Hyatt Roller Bearing plant in Harrison, N. J., on Dec. 27.

Among the numerous operations that were observed were heat treatment of the rollers and cages, blanking and piercing operations for forming the cages, centerless grinding of the rollers and races, and the assembly of the finished bearing.

A question and answer period, with representatives from various departments answering questions pertaining to their specific field of work, closed the inspection trip.

—Edward Arnao

Indiana Technical College

An outline of test facilities which are in operation at the International Harvester Proving Grounds was the subject of a talk, "Road Testing of International Harvester Equipment," by J. C. Mastin, road test department, International Harvester Co.

Indiana Technical College was represented by a large group at this Indiana Section meeting on Dec. 5.

A film entitled "New Champions of

Bausenbach

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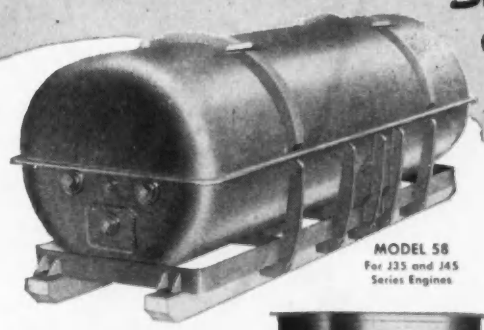

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Transportation" was also shown.

The college orchestra entertained at dinner with a musical interlude.

—Joseph Sbarra, Field Editor

College of the City of New York

Gas turbine powerplants for ground vehicle propulsion are possible, but few competent engineers expect to see them operating commonly within the next decade, Frances L. Weeden observed in a talk at the Nov. 17 meeting.

She explained that proposed units for ground vehicles, like aircraft units, consist essentially of a compressor, burner, and turbine. A large torque is produced by the turbine at low speeds, but unfortunately, the compressor needs a large torque also.

To overcome this difficulty, another turbine is used, on a separate shaft. The load is coupled to this second turbine. Regeneration may be used, Miss Weeden added.

Turbine advantages mentioned are:

1. At low speeds, there is considerable excess torque for acceleration—more than conventional engines of the same maximum power have.
2. Turbine powerplants weigh less.
3. Octane ratings mean nothing to turbines.
4. The absence of power impulses reduces torsional vibration.

Disadvantages are:

1. Operating and first costs are likely to be higher.
2. Fuel consumption is high.
3. High-ratio reduction gearing is required.
4. Turbine engines can not be used for braking on downgrades.
5. Turbine powerplants have poor efficiency off their design points.

According to the speaker, several experimental units have already been built for road vehicles—among them the Boeing Model 502 and the English Rover and Centrax designs.

She indicated that gas turbines may appear first in off-the-highway equipment, then in trucks, before appearing in passenger cars.

Miss Weeden is technical editor of SAE Journal.

—William Novick

University of Colorado

Intense summer temperatures encountered in the Mojave desert and across the Nevada plains and the extreme elevations impose serious problems on trucking operations in the West, according to R. T. Allyne, director of engineering for Pacific Intermountain Express. He spoke at the meeting held Nov. 15.

Pacific Intermountain Express has a fleet of 350 trucks, all of which are the semitractor trailer type and which are constructed to carry the 40,000 lb maximum payload allowed by the I.C.C. The company's fleet travels 25 million miles a year and grosses a million dollars a month in revenues, Allyne said.

"The major problem confronting P.I.E. engineers is tire fires," Allyne said. "Temperatures reaching 120 F in the summer in California and Nevada impose this hazard. The excessive heat built up in the huge tires by a combination of the tremendous weight and the heat of the pavement produce fires that are often impossible for the drivers to extinguish."

Test rigs loaded with rock and equipped with aircraft-type gun cameras are being employed to discover the exact nature of the fire outbreak with different types of tires and under various test conditions, Allyne reported. Methods of warning the driver are also being considered, as the driver is usually unaware of tire fires until considerable damage has been done.

"Numerous extinguishing methods have been experimented with by P.I.E.

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engineers. The common fire extinguisher is practically useless," Allyne said, "and only by restricting the oxygen supply can the fire be stopped. The most effective method found to date is in throwing a chemically treated blanket over the duals to smother the flame, but even with this method the hot gases escaping from the tire often char the blanket, in which case air gets to the tire and it bursts into flame again."

Other research presently being conducted by P.I.E. is in the form of weight economy, according to the speaker. All-aluminum trailers offer no further weight reduction in their construction, but weight reduction by way of forged aluminum wheels is being investigated. Several sets of these wheels are now undergoing tests on company trucks, and if they prove successful it will mean a weight saving of 42 lb per wheel over the conventional wheel or 798 lb per truck, allowing an increase in the payload of that amount.

Experimentation is in progress with different types of paint for the trailers for the purpose of finding a paint that is lighter, that will last longer and look better. Research is also being carried on to find the quietest muffler possible in the interest of public relations, Allyne said.

Complete records are kept of every tire for its entire life, even after 3 or 4 recaps and mileage on the tires is known at all times. P.I.E. follows the policy of using only new tires on front wheels and, after the tread is three-quarters gone, changing them to the rear duals where they are run smooth. By recapping several times, the company frequently obtains up to 280,000 miles on a single tire carcass.

According to Allyne, P.I.E. was the first trucking company to employ the TWX communication system. Through the use of this system, together with a dispatch board in Denver, the company keeps track of all its carriers so that it can trace any particular truck at any time for its customers. With TWX the main office is able to determine the exact tonnage on the road and waiting in the docks at any time, promoting maximum operating efficiency.

—Les Johnson, Field Editor

Lawrence Institute of Technology

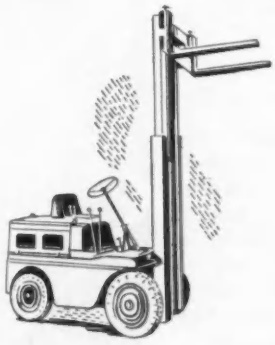
The engineering section of the modern automotive corporation is a system of individual units whose specific work must be closely coordinated with the work of all other engineering, manufacturing, finance, and sales units. Unless this coordination is attained, no manufacturer can hope to achieve the efficiency necessary to overcome present-day competition.

This opinion was expressed at the Nov. 18 meeting by Robert Hazard, chairman of the Detroit Section and design engineer for the Chevrolet Motor Division, GMC.

Successful plant operation requires that the engineering section constantly consider the cost and sales value of every proposed improvement; that manufacturing processes be kept at a minimum through proper product design; and that quality be kept at as high a standard as successful plant operation will permit. These goals can be attained only by constant cooperation between all departments concerned.

Hazard also pointed out that it requires three years to develop an engine assembly, four years for a transmission, and a corresponding amount of time for other units. Thus in the last months of this year, the automotive engineering departments are working on design problems for the 1952 model, the final tests and releases

YA RADIATORS PROVIDE *REAL* PROTECTION FOR INDUSTRIAL TRUCK ENGINES



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HEAT TRANSFER PRODUCTS DIVISION BELOIT, WISCONSIN

for the 1951 model, the manufacturing problems for 1950, and the service problems for the 1949 model.

—R. J. Gavin, Field Editor

Oregon State College

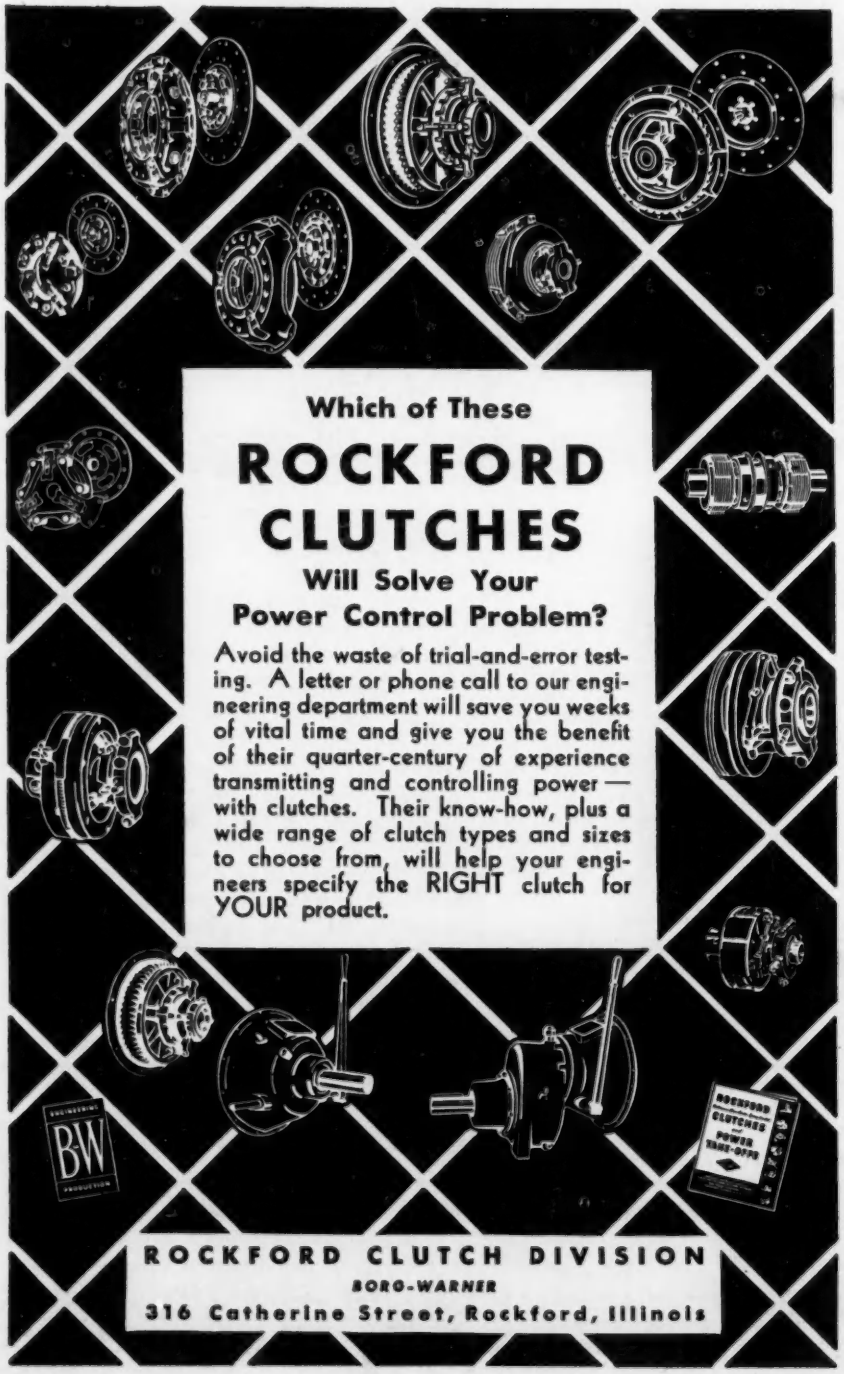
The fall term field trip to Portland took place on Nov. 18.

Starting in the basement of the new Equitable Building the members were shown the heat pumps used to heat and cool the building and the deposit vault of First Federal Savings and Loan. Then from the roof, members saw equipment for lowering window washers and the elevator control room.

Following luncheon as guests of the Oregon Section, the student members continued on to the Bonneville Power Administration where they were shown the test panel used to work out problems of proposed changes in the Northwest power pool.

Concluding the trip at the Kinkade Tool & Machine Co., the group was shown a thread grinding machine in operation.

—L. W. McKee, Field Editor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BORG-WARNER
316 Catherine Street, Rockford, Illinois

Applications Received

The applications for membership received between Dec. 10, 1950, and Jan. 10, 1950 are listed below.

Baltimore Section

Valentine F. Pabst.

British Columbia Section

William Alfred Stroyan.

Buffalo Section

Robert W. Kimpton.

Canadian Section

H. L. Barre, Harold C. Brindle, J. Don Ferguson, Alfred L. Hay, E. G. Jennings, Cyril Patrick Hope Johnstone, David Kaufman, L. Wesley Maxwell, Frederick Hayward Moody, Thomas Leonard Orford, Fred T. Shaw.

Central Illinois Section

John E. Griner, Edward H. Leavitt, Jacob S. Smith.

Chicago Section

Roy B. Bender, Ralph C. Boyle, Charles C. Colyer, Stanford J. Friedman, John Hamilton, Julius Hezler, Jr., David H. Holmgren, Jr., Hollis B. Letson, Bernard Yale McCarty, Maurice T. Moler, Otto J. Wolfer, W. Leland Zink.

Cincinnati Section

Andrew W. Hittle.

Cleveland Section

Stewart E. Gail, Paul E. Haiss, K. Stanley Hawkins, Otis Emery Herweg, Paul I. Nielsen, Richard Louis Riedel, Harold R. Smiley, Michael V. Staursky, Robert W. Underwood.

Colorado Group

William H. Pingree.

Dayton Section

Roger M. McClung, John L. Roberts.

Detroit Section

George Bennett, Gerald E. Bickford, Bengt A. Brogen, Edward R. Davies, Lloyd H. Diehl, Jr., A. H. Esper, William Clay Ford, A. L. Franklin, Karm M. Greiner, Harry Harlow, Zbigniew Joseph Karczewski, Michael B. Kosowan, Ake Larborn, Gordon J. LeBrasse, Benard L. Maas, Jr., William David Morcom, Horace Prunk, Albert E. Samson, Herbert M. Seeger, Theo F. Sharp, Roscoe M. Smith, Melvin Fredrick Sterner, Sumner B. Twiss.

Hawaii Section

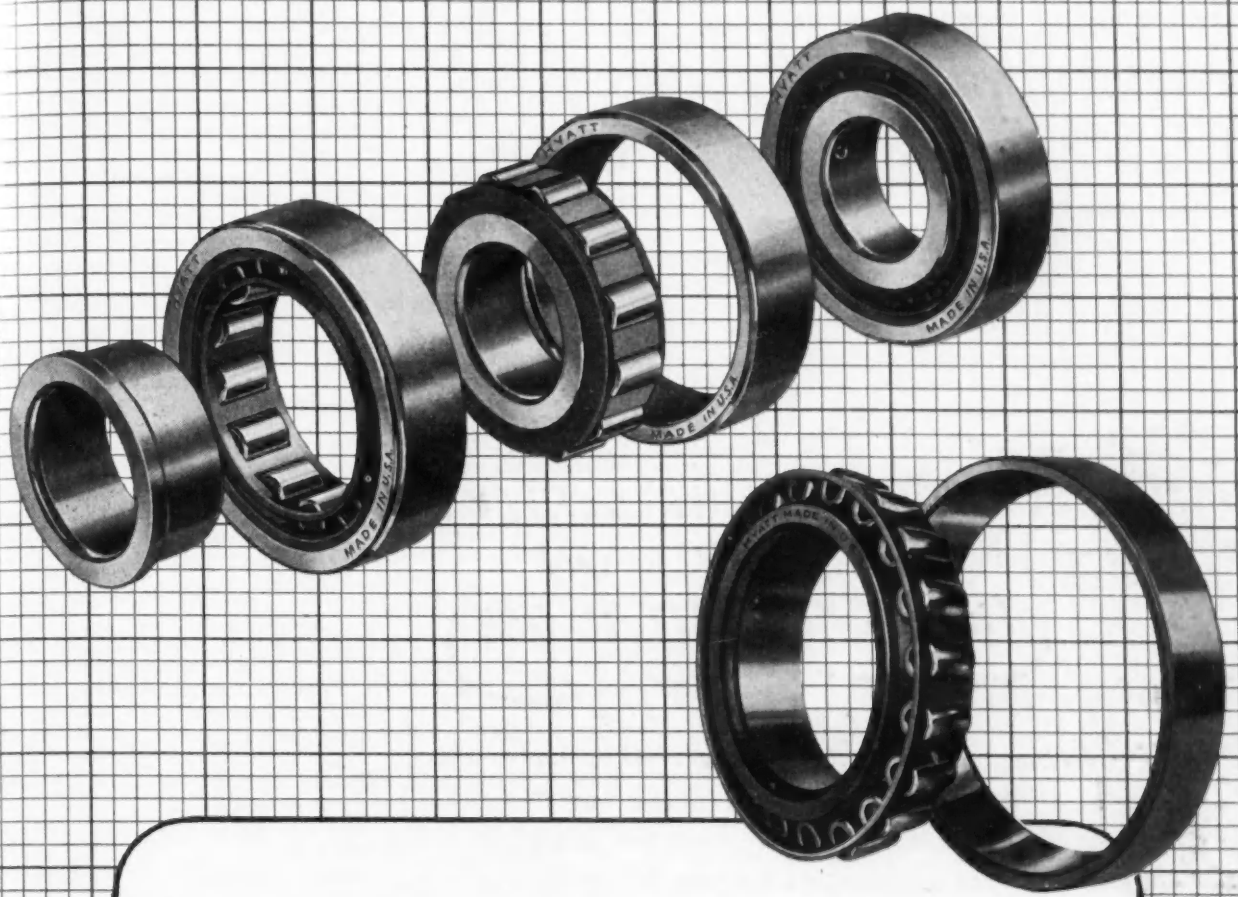
Wallace T. Waterhouse.

Kansas City Section

Norman R. Parmet.

Metropolitan Section

Fred W. Berger, Louis R. Continere,



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Northern California Section

Frank Morgan.

Northwest Section

Rudolph Winslow Fredericks, Floyd R. Ritchie.

Oregon Section

Michael Petri.

Philadelphia Section

Irvin R. Whiteman.

St. Louis Section

Earl L. Hoffmann.

San Diego Section

Machlin B. Laddon.

Southern California Section

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Syracuse Section

V. A. MacMillan.

Texas Section

Howe M. Carey, Burnett S. Fuess, Richard C. Marr.

Twin City Section

Warren W. Beehler.

Virginia Section

Fleming L. Lippy.

Washington Section

Conrad R. Hilpert, Henri Polak.

Western Michigan Section

Hubert D. Burnside, Carl Lund.

Outside of Section Territory

John H. Edman, Henry Earl Farnam, Jr., Robert William Hayes, Milton Melbourne Wylie.

Foreign

Arthur Stewart Bray, Iraq; George Kenneth Martlew, England; Lt.-Col. T. B. Poduval, India; Peter Ralph Purves, England; K. Ramachandran, India.

New Members Qualified

These applicants qualified for admission to the Society between Dec. 10 1949 and Jan. 10, 1950. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

Baltimore Section
Thomas Morgan Potts (J).

British Columbia Group
Marshall Alexander McPhail (A).

Buffalo Section
John Dellon Walsh (J).

Canadian Section
Walter Bedford (J).

Chicago Section
Robert S. Alexander (J), Harlan H. Davis (M), Howard C. Grossenheider (M), Franz Richard Hildebrecht (J), Stephen Michael Hitchcock (J), Peter R. Hoffmann (J), Robert Edward Wilson (J).

Cleveland Section
William Ellis Davidson (A), Harry J. McDevitt (M), Ralph F. Shard (J), John P. Tierney (M).

Dayton Section
Fred A. Irwin (A).

Detroit Section
Julius Alberani (J), Robert Anderson (J), Arthur C. Bodeau (J), Louis Joseph Danis (M), Simon D. Den Uyl (A), Matthew E. Fiscus (M), Charles L. Foreman (M), Daniel A. Hirschler (M), Clayton W. Kerr (J), Terry W. Kuhn (A), Ward P. Mann (J), Jack Ernest Martens (M), Thomas N. McVetty (J).

Indiana Section
Glenn W. DeVault (A), Marion L. Fast (M).

Metropolitan Section
Henry F. Capell (J), Walter E. Carpenter (M), William C. Hennecke (M), Lester Blaine Searer, Jr. (J), William Steinle Siebert (J), Paul Slysh (J), Henry James Sugerman (J), George Cameron Taylor (M), Bruce Nelson Tuttle (J).

Milwaukee Section
Wallace H. Jerstad (M).

New England Section
O. E. Johnson (A), Thomas J. Lavin (A).

Northern California Section
Don G. LaRue (M).

Northwest Section
R. G. Fender (A), Michael Guidon, III (M), Robert Wm. Jeffs (A), Dean S. Kasper (A).

Oregon Section
Robert E. Allan (M), Roscoe Wilson

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2. Trace scanning for observation of steady state phenomena.
3. Remote control unit.
4. Automatic record numbering system.
5. Automatic record length control.
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Southern California Section
Norbert Stark Gurell (J), Roy E. Marquardt (M), Roy J. Porter (J).

Spokane Intermountain Section
William Howard Swalwell (A).

Virginia Section
E. H. Marsteller, Jr. (A).

Wichita Section
Robert W. Burnham (J).

Williamsport Group
Merrell R. Fenske (M), Samuel Dominick Greco (J), Harry Guttman (J), William Ribando (M).

Outside of Section Territory
Everett K. Bard (M), Donald R. Basham (J), John H. Dittfach (M), Wymer G. Vogel (J), Richard Miller Weatherly (J), Raymond A. Weigel (A).

Foreign
Walter Base (M), Germany; Alan Reeve Croft (FM), England; Ivan Johann Haupt (A), So. Africa; John Glyn Jones (FM), Africa; Kenneth Alban Wright (FM), England.

HAVE YOU Changed Your Address?

So that your SAE mail will reach you with the least possible delay, please keep SAE Headquarters and the Secretary of your local Section or Group advised of any changes in your address. Such notices should be sent to:

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2. The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:

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(Miss) C. M. Hill, 7016 Euclid Ave., Cleveland 3, Ohio

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Fred Schwenk, Fred's Auto Hospital, 1522 Xenia Ave., Dayton 10, Ohio

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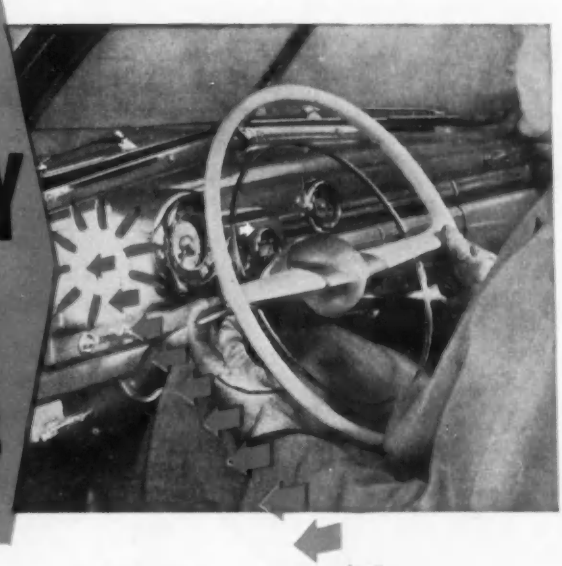

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